FOCUS ON

# Heavy mineral processing and picking

EXPLORE

NUMBER 133 DECEMBER 2006

Newsletter for the Association of Applied Geochemists

## Overview of labs

The application of indicator mineral methods to mineral exploration has grown and developed significantly over the past two decades. They are used around the world to explore for a broad spectrum of commodities. Heavy mineral suites now exist for detecting a variety of ore deposit types including diamond, gold, Ni-Cu, PGE, porphyry Cu, massive sulphide, uranium, and tungsten. Because of this important development in exploration methods, this issue of **EXPLORE** is focused on laboratory methods used to recover and pick indicator minerals from surficial media and bedrock. Several labs were invited to provide overviews of their particular lab procedures and services, most labs welcomed the invitation and their contributions to this issue of **EXPLORE** are greatly appreciated. Other heavy mineral processing labs that are not included in this first focus issue are encouraged to contact me directly and to make a contribution to subsequent issues of **EXPLORE**.

For those interested in the application of indicator mineral methods to mineral exploration, a 1-day indicator mineral workshop entitled 'Indicator Mineral Methods in Mineral Exploration' will be held in Toronto, Canada in September 2007. This workshop is being held in association with ***Exploration 07,*** the Fifth Decennial International Conference on Mineral Exploration. The workshop is co-sponsored by the AAG. The indicator mineral workshop will cover the following topics: survey design, sample processing, mineral chemistry, QA/QC, precious metal exploration, diamond exploration, base metal exploration, contamination, exploration and regional mapping case studies. The ***Exploration*** conferences are a once-in-a-decade global assessment of the state of mineral exploration methods. Additional information about ***Exploration 07*** is available at http://www.exploration07.com/. I hope to see many AAG members in the workshop and at the conference!

**Beth McClenaghan**
*Editor*, **EXPLORE**

## Overburden Drilling Management Ltd: "Exploring Heavy Minerals"

**THE COMPANY**

Overburden Drilling Management Limited (ODM) maintains its head office and laboratory in Nepean (Ottawa), Ontario, Canada. The company was formed 32 years ago (1974) by geologist Stu Averill. Its sole business since inception has been exploration using indicator mineral methods, initially for uranium, then gold and today a wide range of commodities. With a staff of 30 including 11 geologists, ODM offers a full spectrum of heavy mineral services ranging from complete exploration programs to indicator mineral processing/picking, ore mineral distribution studies and forensic investigation of sample contamination and tampering problems. All indicator mineral picking is performed by the company's geologists (Fig. 1) rather than by technicians. The geologists consider the

***Figure 1*** *- ODM geologists picking indicator minerals.*

continued on page 2

## TABLE OF CONTENTS

## Focus on: Overburden Drilling...

continued from page 1

significance of all heavy minerals present in a sample rather than simply noting one type such as kimberlite indicator minerals (KIMs). This approach has led to the recognition and utilization of special mineral suites indicative of a wide range of mineral deposit types. These include magmatic/metamorphosed massive sulphide indicator minerals (MMSIMs®), with separate subsuites for Ni-Cu-PGE, Broken Hill-type (BHT), volcanogenic massive sulphide (VMS), iron oxide-copper-gold (IOCG), Mississippi Valley-type (MVT) and skarn deposits, and porphyry Cu indicator minerals (PCIMs®). Most of the above indicator minerals are of a similar size and specific gravity and, with appropriate processing, can be recovered simultaneously.

ODM and its principal geologists are members of the Association of Professional Geoscientists of Ontario. The company also has a very active Joint Health and Safety Committee. With a laboratory capacity well over 10,000 samples per year, ODM has processed all types of sediment samples and many rock samples from diverse climatic environments on nearly all continents. Turnover of key staff has been minimal and the company has accumulated a wealth of indicator mineral processing and interpretation experience. ODM's slogan is "Exploring Heavy Minerals" and its goal is to provide comprehensive, research-grade data at practical exploration prices. The company's clients include many major and junior mineral exploration companies and 15 national, provincial and state geological surveys.

### SAMPLE PROCESSING

Indicator minerals in general are: (1) chemically stable in weathered sediments; (2) heavy (concentratable); and (3)

continued on page 3

| Target | Typical Sample Wt. (kg) | Required Separations | | | | |
|---|---|---|---|---|---|---|
| | | Table | Micropan | Heavy Liquid (Specific Gravity) | Ferro-Magnetic | Para-magnetic |
| **A. Sediment Samples** | | | | | | |
| Gold | 10 | Single | Yes | 3.3 | Yes | No |
| Kimberlite | 10-30 | Double | No | 3.2 | Yes | Yes |
| Massive sulphides (Ni-Cu-PGE, BHT, VMS, IOCG, MVT, skarn) | 10 | Single | Yes (PGE only) | 3.2 | Yes | Yes |
| Porphyry Cu | 0.5 | No | No | 2.8, 3.2 | Yes | Two |
| Uranium | 10 | Single | Yes | 3.3 | Yes | No |
| Heavy mineral sands (grade evaluation) | 20 | Triple | No | 3.3 | Yes | Optional |
| Tampering (investigation) | Variable | Optional | Yes | 3.3 | Yes | Optional |
| **B. Rock Samples** | | | | | | |
| Gold, PGE, base metals | 1 | Optional | Yes | 3.3 | Yes | Optional |
| Kimberlite | 1-10 | Optional | No | 3.2 | Yes | Yes |
| Tampering (investigation) | 1 | No | Yes | 3.3 | Yes | Optional |

***Table 1** - Variation in sample size and ODM laboratory separations with sample and target type.*

## Focus on: Overburden Drilling...

continued from page 3

either vivid (*e.g.* gold) or sufficiently coarse grained to be readily identified. Sediment samples processed by ODM typically weigh 10 kg if gold or MMSIMs are targeted or 10 to 30 kg if KIMs are required (Table 1). PCIM processing requires only a 0.5 kg sample because porphyry Cu alteration systems are large and rich in indicator minerals. Rock samples are typically of 1 to 10 kg size.

Indicator mineralogy is hypersensitive; a 20 kg sample of medium sand contains ~300 million mineral grains and the presence of just one grain of some indicator minerals can be significant. Therefore the laboratory processes employed to recover the indicator grains must provide a very high recovery rate and eliminate any potential for carryover between samples. Grains of most indicator minerals are the size of medium to coarse sand (0.25 to 2.0 mm) but 90 percent of gold grains and Pt-group minerals (PGMs) are silt sized (<0.063 mm). This size difference must also be addressed if simultaneous recovery of all indicator minerals is required.

To eliminate grain carryover between samples, ODM employs only processes in which the quality of the mineral separation and evidence of carryover are clearly visible. Enclosed concentrating devices and mechanical sieve shakers are avoided. Most samples except those processed for PCIMs are tabled to obtain a preliminary concentrate (Fig. 2). If kimberlite indicators are targeted, the sample is tabled twice to ensure good recovery of the

***Figure 2** - Heavy mineral preconcentration by tabling, ODM laboratory.*

lowest-density minerals (Cr-diopside and forsterite olivine) and coarsest particles. Gold and PGM grains are separated from the table concentrate by micropanning and are classified by size and degree of wear (*i.e.* transport). The concentrate is then refined by sink-float separation in methylene iodide and subjected to a ferromagnetic separation to remove magnetite and any steel contaminants. For most indicators, the methylene iodide is diluted with acetone to specific gravity (S.G.) 3.2.

continued on page 4

## Focus on: Overburden Drilling... continued from page 3

Acetone is also used to rinse methylene iodide from the sand grains after separation; both liquids are then reclaimed by distillation. To ease indicator mineral identification, the final concentrate is cleaned of oxidation stains using oxalic acid and the fine (0.25-0.5 mm) heavy mineral fraction, which is normally larger and contains far more mineral grains than the other, coarser (0.5-1.0 and 1.0-2.0 mm) indicator mineral fractions, is electromagnetically partitioned into four subfractions – three paramagnetic and one nonparamagnetic. If unweathered sediments are sampled and preservation of uranium minerals and gold-bearing or base metal sulphides is expected, as is the case for glaciogenic sediments sampled by reverse circulation drilling, the unused -0.25 mm portion of the concentrate is submitted for geochemical analysis.

Rock samples are logged by a senior geologist prior to crushing to determine the probable range of indicator minerals present, their grain size and the degree of milling required for their liberation. ODM is presently installing an electric pulse disaggregator to liberate the grains along their boundaries, thereby minimizing grain damage. After milling, large rock samples are typically tabled whereas small samples proceed directly to micropanning and/or heavy liquid separation (Table 1).

**PICKING**

ODM picks indicator minerals from the 0.25-0.5, 0.5-1.0 and 1.0-2.0 mm heavy mineral fractions or such other size fractions as may be specified by the client. For kimberlite, ODM reports eight indicator minerals: Cr-pyrope, Cr-poor pyrope and eclogitic pyrope-almandine garnet, Mg-ilmenite, chromite, Cr-diopside, enstatite and forsteritic olivine. Chromite, Cr-diopside, enstatite and forsterite are also used as Ni-Cu-PGE indicators; therefore special cross-referenced data tables are used on projects where both sets of indicators are targeted. PCIM indicators also require two data tables, one for each specific gravity range used in the separations (Table 1). On all indicator mineral projects, ODM systematically lists the principal paramagnetic versus nonparamagnetic heavy minerals present in the 0.25 to 0.5 mm fraction, thereby establishing a background mineral assemblage that is unique to the sample. This assemblage fingerprints the overall provenance of the sample and the potential source regions of any contained indicator minerals.

Although ODM's picking is performed by experienced exploration geologists, questionable mineral grains are encountered in some samples. ODM employs an on-site scanning electron microscope (SEM) with energy dispersive x-ray analyzer (EDS) to immediately resolve such grains. This eliminates downstream wastage on electron microprobe analyses, ensures consistent data reporting between samples, geologists and projects and allows the use of certain indicator minerals such as spessartine garnet, which cannot be positively identified from visual characteristics alone. Due to the specialized nature of the data, ODM supplies, at no extra charge, a summary interpretation of significant anomalies using its broad exploration experience.

**QUALITY CONTROL**

ODM's most obvious quality controls are: (1) the complete visibility of the mineral separation process at all stages which provides a continuous series of visual checkpoints; and (2) the fact that the samples are picked by experienced exploration geologists who quickly recognize every natural mineral species present and therefore perceive any unnatural mineral grains or other contaminants. However, with so many fractions and subfractions being produced from each sample, the potential for unrecognized mix-ups is significant. ODM addresses this concern by weighing all fractions before and after each procedure and tallying the weights. Any errors, no matter how minor, are reported to the client in writing.

Gold grains, being very dense, mostly silt sized and invisible to the naked eye, are particularly susceptible to carryover between samples; they tend to lodge in the tiniest crevices in any type of concentrator. However, ODM observes the grains in the first (tabling) concentration step, quickly identifying any anomalous samples and adding appropriate blanks before processing the next sample.

**RECOVERY RATES**

ODM's laboratory is designed to provide high recovery of all heavy minerals even if these minerals differ considerably in grain size and specific gravity. Using shaking tables is important because tables can recover a wider size range of heavy mineral grains than any other gravity concentrator. ODM extensively customizes its tables to significantly raise both recovery rates and concentrate quality. Gold and PGM recovery rates are sufficient, even at 10 to 20 microns, to quantify the contribution of these species to geochemical anomalies as required in forensic and mineral deposit investigations. For KIMs, the company uses internal spike tests to measure and control recovery rates and fully discloses the test procedures and results to its clients. These annual tests are objective, totally blind, extend over several

continued on page 5

## Focus on: Overburden Drilling...

continued from page 4

months, utilize most of the laboratory equipment and personnel, and employ regular samples and natural, imperfect indicator minerals; they do not embellish the lab's performance. An important feature of the tests is the reprocessing all rejects to account for any KIM losses. This annual testing has resulted in steady, incremental improvements such that recovery rates in the 2005 test ranged from 83 percent for Cr-diopside to 97 percent for chromite. Such advances help ODM meet its goal of offering comprehensive, research-grade data to all clients at practical exploration prices.

**Stu Averill**, President
**Rémy Huneault**, Laboratory Manager
*Overburden Drilling Management Limited*
*107 - 15 Capella Court*
*Ottawa, ON, CANADA K2E 7X1*
*tele: 613-226-1771*
*Email: odm@storm.ca*

## Industry Leading Laboratory Services for Diamond Explorers

### INTRODUCTION

Mineral Services Canada (MSC) offers specialized laboratory and analytical services to the diamond exploration industry. Our facility in North Vancouver, British Columbia, Canada, includes a Diamond Exploration Laboratory and an Indicator Mineral Sorting Laboratory. In addition we have access to a number of reputable analytical facilities that allow us to offer a comprehensive range of services. The MSC operations complement the existing Mineral Services Laboratory located at the company's office in Cape Town, South Africa. Over the past 10 years, the Mineral Services group has developed several specialized techniques that have been proven to be effective aids to kimberlite exploration and evaluation programs. The Vancouver facility has been operating for 3 years and our ongoing research and development and close contacts with industry and academia ensure that these facilities maintain industry leading technical procedures. Stringent quality control ensures reliable results, and the laboratory runs a comprehensive in-house data management system that tracks and captures information at each step of the laboratory process.

### MSC DIAMOND EXPLORATION LABORATORY

MSC Diamond Exploration Laboratory applies specialized techniques for the liberation and concentration of heavy minerals from unconsolidated surficial materials and kimberlite rock samples.

#### Processing of unconsolidated exploration samples

MSC has developed a procedure for the consistent and accurate recovery of diamond indicator minerals from unconsolidated exploration samples, including but not limited to tills, soils and stream sediments. The ideal weight for an exploration sample for our circuit is 10 to 25 kg, however there is no processing weight restriction. A detailed flow-sheet illustrating the sample processing circuit is provided in Figure 1.

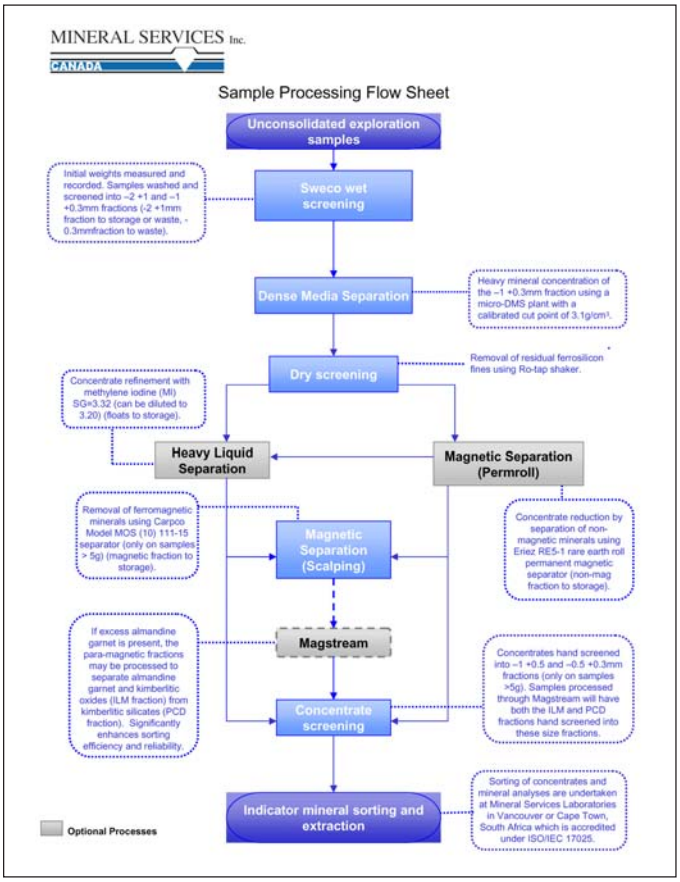



***Figure 1.*** *Sample processing flow sheet.*

The key technology used at our facility is North America's first laboratory scale micro-DMS plant that has been successfully incorporated into our heavy mineral concentration procedure. Over ten years of research and development by Dowding, Reynard and Associates and others has perfected the technology to achieve the accuracy and repeatability required for batch mode laboratory applications. DMS technology is clean (non-toxic), fast, accurate and reliable. It is also less susceptible to sample contamination than conventional heavy mineral concentrating techniques currently in use in the exploration industry.

continued on page 6

## Focus on: Mineral Services Canada...

continued from page 5

In the DMS plant, separation is achieved in a gravity-fed high-pressure cyclone (Fig. 2). The sample is mixed with ferrosilicon (FeSi) slurry of controlled density and fed into the cyclone where separation of the heavy mineral fraction from the light minerals is effected. The heavy mineral concentrate is collected on a 0.25 mm screen and is then dried and screened on a rotap shaker to remove any residual FeSi from the concentrate. Depending on client requirements, a number of additional processes can be applied to further refine the concentrates. These are explained in more detail below.

The efficiency and precision of the DMS separation process is defined by a Tromp Curve (Fig. 3). The cut-point spans a density range of 0.2 g/cm$^3$ at ~3.1 g/cm$^3$ and has been carefully calibrated to quantitatively recover the common diamond indicator mineral species greater than approximately 3.1 g/cm$^3$, pyrope garnet, chrome-spinel, ilmenite, chrome diopside, forsteritic olivine and diamond. The required cut point is established using the computerized control panel on the DMS and the Tromp curve is then tested using synthetic density tracers prior to commencing with production. The DMS plant is designed to recover indicator minerals in the size range -6 to +0.3 mm.

During the DMS commissioning phase, numerous tests were undertaken in order to establish optimum performance. Natural kimberlite indicator minerals (-2 +0.3 mm) together with synthetic density tracers (0.8 mm) and synthetic diamonds (0.5 mm) were used to calibrate and test plant performance over a wide range of sample background compositions and grain-size ranges. In terms of natural indicator mineral grains, standard tests involved the introduction of 100 grains of each of the common

continued on page 7

***Figure 2.*** *Photograph of the micro-DMS unit.*

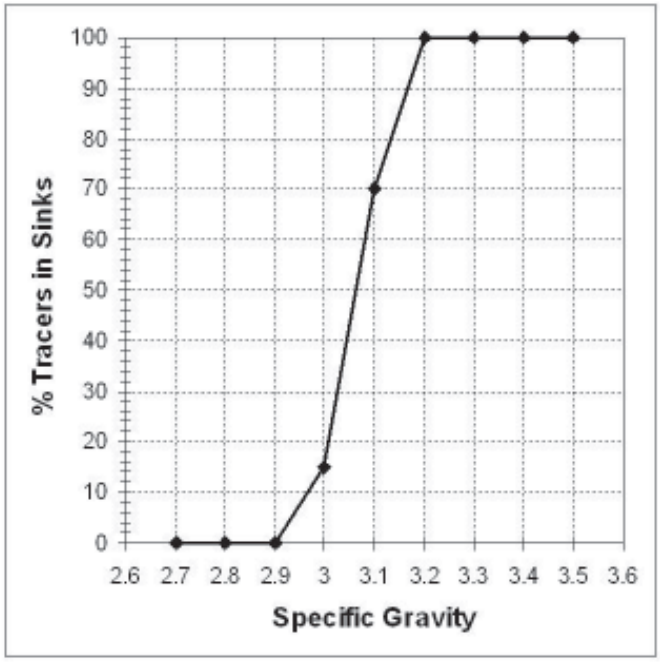



***Figure 3.*** *Tromp curve used for establishing the density of the DMS concentrate product.*

## Focus on: Mineral Services Canada...

continued from page 6

indicator mineral species. Results were beyond expectation in that not a single indicator mineral grain was lost during the entire testing process, which involved over twenty tests performed under a variety of conditions. Routine quality control (QC) testing introduced since the laboratory commenced commercial production has been equally impressive.

As is noted on the sample processing flow sheet, a number of addition post-DMS processes are available to further refine the heavy mineral concentrate produced by the DMS. The first such process is a heavy liquid separation using methylene iodide (MI), either at full strength (density = 3.32 g/cm$^3$) or diluted (density = 3.2 g/cm$^3$) depending on the nature of the concentrate and the importance of retaining 100% of the chrome diopside in the concentrate. This process is outsourced to a reputable third party laboratory in Vancouver. The post-MI concentrate is then commonly passed through our Carpco magnetic separator to remove the ferromagnetic minerals from the concentrate. If the non/para-magnetic portion of the concentrate contains significant almandine garnet or a particularly high concentration of oxides, then it is further processed through a magstream that splits the concentrate into a "pyrope" fraction containing most of the silicates, and an "ilmenite" fraction containing ilmenite, chromite and other moderately magnetic minerals such as almandine. The concentrates are then screened into appropriate size fractions for sorting, typically 0.3-0.5 mm, and 0.5-1.0 mm.

**Processing of kimberlite samples for evaluation of diamond potential**

Mineral Services has developed the Mantle Mapper™ procedure for quantitatively assessing the abundance and chemical composition of key indicator minerals in samples of kimberlite. Analytical results permit reliable appraisal of the diamond potential of the host body and of the nature and general prospectivity of the mantle that it has sampled. The method is particularly useful in the early stages of kimberlite evaluation. Rigorous and consistent sample processing, picking and analytical procedures are employed to ensure that the data obtained are representative, quantitative and reproducible. The method has been applied in numerous projects worldwide and it has proved highly successful, both for prioritizing kimberlites for further evaluation work and for assessing the overall prospectivity of the regions intruded by the kimberlites. Some of the key advantages of using Mantle Mapper include:

- It provides a robust means of qualitatively determining the diamond potential of individual kimberlites and, in conjunction with petrographic and microdiamond data, provides a basis for decisions on whether more costly additional evaluation work is justified.
- Because indicator minerals are significantly more abundant than diamond in most kimberlites, Mantle Mapper analysis is statistically sound and provides a reliable indication of the nature and diamond potential of the sampled body.
- It provides a very important backup to microdiamond analysis, which can yield misleading results due to factors such as limited sample size and resultant statistical uncertainty, uncertainty regarding the relationship between micro and macrodiamonds, and coarse stone-size distributions that are not adequately sampled/tested by the relatively small samples typically treated for microdiamonds.
- Because the method is standardized, if consistently applied, it provides a reliable basis for comparison (and prioritization) of different kimberlites (particularly within specific kimberlite clusters or fields) and of different phases within a single kimberlite body.
- Mantle Mapper results provide a means of assessing the prospectivity of the region in which the kimberlite occurs. A low diamond content / potential in a particular kimberlite does not necessarily rule out the presence of diamondiferous bodies in the area in which it occurs. In many cases, however, the low diamond content of a kimberlite reflects regional factors that significantly limit the potential for other diamondiferous bodies nearby. These factors are typically evident in the Mantle Mapper results.

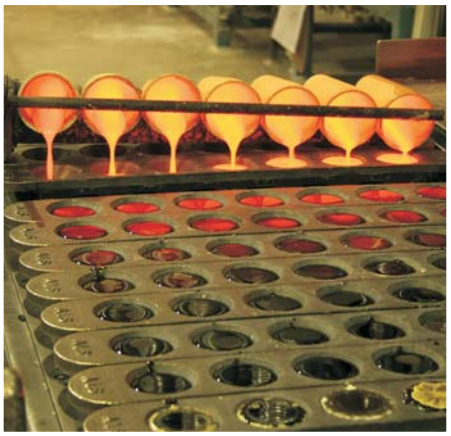
The minimum recommended weight of kimberlite sample submitted for Mantle Mapper characterisation is 5 to 10 kg. A key requirement for successful application of this method is that the sample is fully representative of the kimberlite / phase being evaluated.

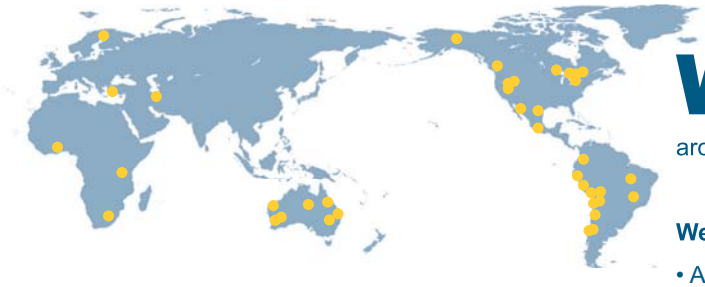
continued on page 9

# ALS Laboratory Group

ANALYTICAL CHEMISTRY & TESTING SERVICES

## Mineral Division - ALS Chemex





We are a global analytical testing company serving the mining and mineral exploration industry in 17 countries around the world.

**We specialise in:**

- Assaying and geochemical analysis for mining and mineral exploration projects
- On-site contract mine laboratory management
- Environmental monitoring for mining operations
- Acid mine drainage studies

Contact the ALS Chemex laboratory nearest to you to find out how we can help you with all of your project's analytical needs. Detailed contact information for individual locations can be found on our website.

**www.alschemex.com**

*Right solutions....*
*....Right partner*

## Focus on: Mineral Services Canada... continued from page 7

**Indicator Mineral Sorting Laboratory**

Heavy mineral concentrates from unconsolidated exploration samples, kimberlite samples and microdiamond caustic fusion residues are examined microscopically by a team of highly trained mineral sorters (Fig. 4). MSC mineral sorters are trained in identifying and recovering kimberlitic varieties of the following mineral species: garnet, spinel, ilmenite, clinopyroxene, olivine, orthopyroxene, and diamond. Standardized microscopes and light sources are used by each sorter for examination of the concentrate. Our laboratory routinely observes exploration and rock sample heavy mineral concentrates down to 0.25 mm, while caustic fusion residues are examined down to 0.075 mm for microdiamond extraction.

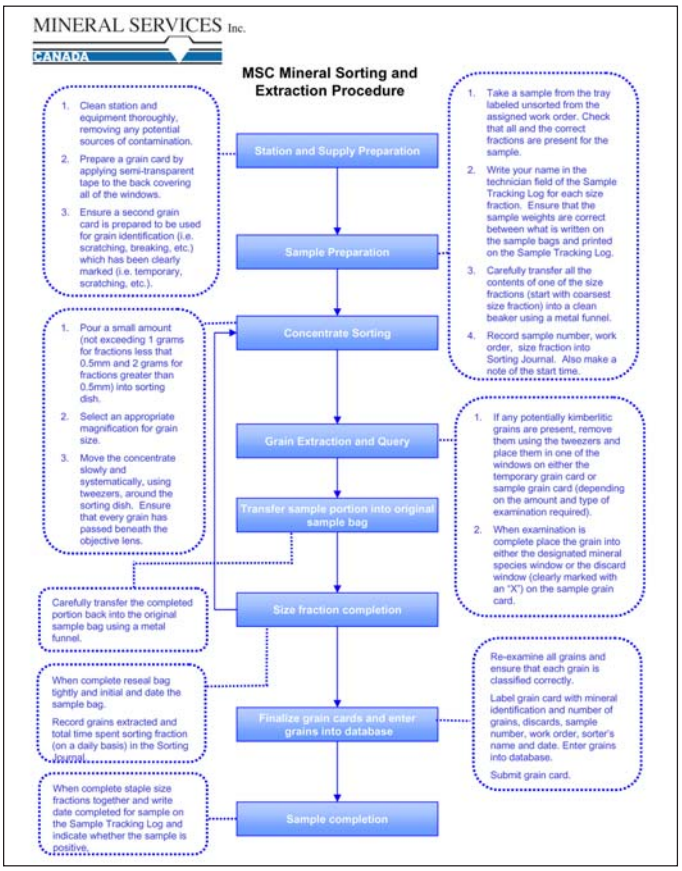



***Figure 4.*** *Mineral sorting and extraction flow sheet.*

Quality-control (QC) procedures include the re-examination of between 10 and 100% of the samples in a batch, depending on the complexity of the background mineralogy and the results of ongoing QC on any particular batch. Under normal conditions, kimberlitic indicator mineral recovery efficiencies from first-pass sorting are expected to be better than 85%. Sorting rates vary considerably depending on the grain size, background mineralogy and the abundance of indicator minerals in the sample, but are typically in the range of 4 to 20 g/hr. Typically, both the 0.3-0.5 mm and 0.5-1.0 mm concentrate sizes are examined for indicator minerals, and results are reported in the form of abundances per size fraction per sample. In cases where it has been impractical to examine the entire concentrate fraction, both the original weight and sorted weight of concentrate are recorded which allows for the results to be accurately normalised. Riffle splitting of the concentrate prior to sorting is another method of reducing sorting time and cost. Sample results are issued in the form a hard-copy pdf format report, plus a digital copy of the data in MS Excel® format. Both are extracted directly from the laboratory database. The indicator minerals extracted from exploration samples are described and classified according to their surface features and angularity, parameters that can be related to transport distance from their kimberlite source.

**Analytical Facilities**

Minerals recovered from exploration and rock sample concentrates typically undergo a full quantitative analysis in order to confirm their kimberlitic origin and mantle paragenesis. This analysis is most commonly undertaken at the in-house analytical facilities at Mineral Services Laboratories in Cape Town, South Africa. The Cape Town laboratory has a modern LEO 1450 Scanning Electron Microscope fitted with Oxford Instruments wave-length dispersive (WD) and energy dispersive (ED) spectrometers. Detection limits for major elements measured by ED are 0.1 wt%, while minor elements measured by WD are detected down to 0.01wt%. MSC also has an arrangement with the University of British Columbia for regular access to their SEM facilities, which allows for confirmation of the identity of difficult or rare mineral species that cannot be unequivocally recognized by optical techniques alone.

In 2005, Mineral Services participated in a round robin proficiency test for the analysis of homogeneous minerals and glasses. The international test was organized and monitored by four research scientists, from the Open University, Milton Keynes, UK., Birkbeck College, London, UK and the USGS, Denver, Colorado, USA. Sixty-four laboratories participated, and the Mineral Services result for a basalt glass prepared at the USGS (NKT-1G) is presented below in Table 1. This result has been assessed to be of an extremely high standard by the scientific panel running the test.

Trace element analysis is routinely conducted on a selection of the peridotitic garnets recovered during the Mantle Mapper™ process. This analysis undertaken primarily in order to determine the depth of origin of

continued on page 10

## Focus on: Mineral Services Canada... continued from page 9

| Elements | Standard Values % | (Diff) | Mineral Services Measurements % | 64 Lab Range % |
|---|---|---|---|---|
| $SiO_2$ | 38.68 | (-0.13) | 38.55 | 35.4 - 42.0 |
| $TiO_2$ | 3.95 | (-0.10) | 3.85 | 3.7 - 4.4 |
| $Al_2O_3$ | 10.20 | (-0.01) | 10.09 | 8.3 - 12.1 |
| $Fe_2O_3T$ | 13.31 | (-0.08) | 13.39 | 11.6 - 15.1 |
| MnO | 0.21 | (-0.01) | 0.20 | 0.12 - 0.29 |
| MgO | 14.33 | (+0.02) | 14.35 | 12.0 - 15.1 |
| CaO | 13.21 | (+0.03) | 13.24 | 11.6 - 14.5 |
| $Na_2O$ | 3.48 | (-0.06) | 3.42 | 2.4 - 4.5 |
| $K_2O$ | 1.28 | (-0.03) | 1.25 | 0.99 - 1.59 |
| $P_2O_5$ | 0.97 | (+0.01) | 0.98 | 0.62 - 1.31 |

***Table 1.*** *Mineral Services analytical results for basaltic glass NKT 1-G.*

these grains, in particular whether they are derived from the diamond stability field. This work is undertaken on standard mineral grain mounts using a Perkin Elmer / Sciex Elan 6000 laser ablation inductively coupled plasma - mass spectrometry (La-ICP-MS) system at the Department of Geological Sciences at the University of Cape Town. The La-ICP-MS provides highly reproducible trace element data with very low detection limits (e.g. ~ 1 ppm, for Ni in garnet). Ni-in-garnet thermometry as well as REE analyses are routinely undertaken using this analytical technique.



### MICRODIAMOND EVALUATION AND MODELING

Microdiamond evaluation and modeling can be an effective tool in the prediction of value and grade of the macrodiamond population at a given locality. To this end, individual microdiamonds are weighed and described according to a set of criteria developed for this purpose. The critical value criteria are based on a scheme developed by Dr. John Gurney on the basis of extensive experience in looking at microdiamond populations. The size distribution patterns of a microdiamond population can be used to model the possible grade ranges of the corresponding macrodiamond population, providing that a suitable number of stones covering a range of sizes are present. Individual microdiamonds are weighed down to a detection limit of 0.01 mg, and the smaller stones are group weighed. The MSC lab in North Vancouver undertakes the sorting of residues and also the weighing and description of individual microdiamonds. The size distribution and grade modeling work is then carried out by one of the Mineral Services geological consultants.


**Mike Baumgartner**
*Mineral Services Canada*
*205-930 Harbourside Drive*
*North Vancouver, British Columbia*
*V7P 3S7 CANADA*
*Tele: 604-980-6771*
*Email: mike.baumgartner@mineralservices.com*


## Kimberlite Indicator Mineral Services offered by SRC Geoanalytical Laboratories

### INTRODUCTION

Founded in 1947, the Saskatchewan Research Council (SRC) is a leading provider of applied research and development and technology commercialization in the province of Saskatchewan, Canada. SRC offers a wide range of professional and technical expertise, including laboratory services. SRC Geoanalytical Laboratories is a world-class facility that has been providing high quality analysis to the mining industry since 1972. The facility is located in Saskatoon, Saskatchewan, Canada close to the University of Saskatchewan campus. This close proximity facilitates close collaboration between the two organizations. SRC Geoanalytical Laboratories provides excellent services to clients. The Laboratories are ISO 17025 accredited for specific processes and are continually audited by internal and external parties to ensure that all facilities are adequate to carry out the services provided for the customer.

SRC provides quality services that are relevant, timely and cost-effective. A broad spectrum of services to the exploration industry is provided by Geoanalytical Laboratories. The Diamond Laboratory has firmly established a reputation as an independent lab that provides reliable, high-quality services in diamond exploration. Services offered include:

continued on page 11

## Focus on: SRC Geoanalytical Laboratories... continued from page 10

- Caustic fusion analysis
- Kimberlite indicator minerals processing of till and rock samples
- Mineralogical services (mineral identification, photography, SEM and electron microprobe analysis)

The Geoanalytical Laboratory processes 5,000 to 15,000 tills samples per year based on customer needs. Sample weights can vary from grams to 30 kg but typically, tills samples range from 10 to 30 kg. (Fig.1)

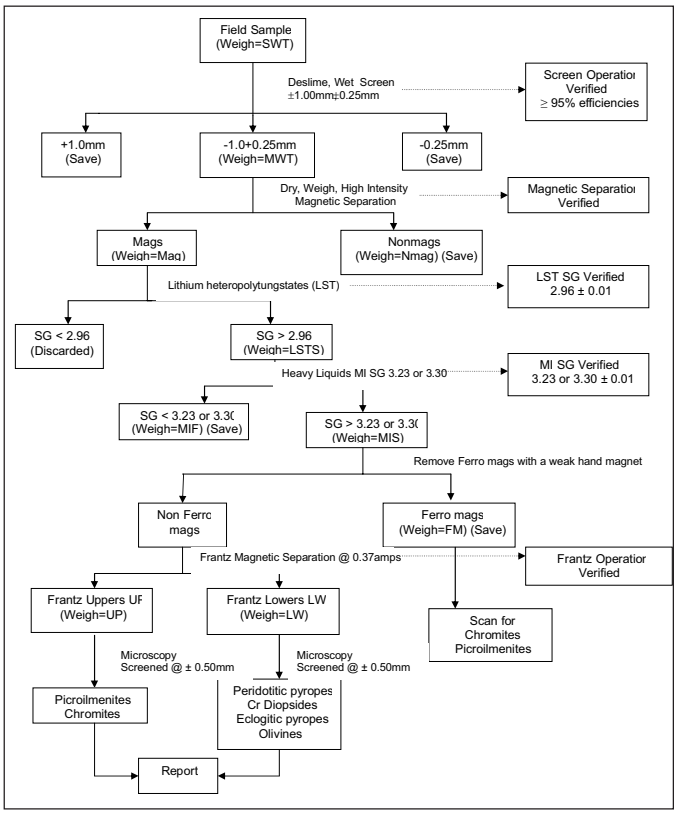



***Figure 1**. Kimberlite indicator mineral-specific methods for processing and observation of till samples, steam sediments etc.*

### RECEIVING SAMPLES

When samples arrive from the field they are sorted numerically, a packing slip is generated and a chain of custody form is created. A complete Chain of Custody form includes: sample list, the date shipped, the date received, assigned SRC group numbers, and proposed method of processing and observation as instructed by the customer. The Chain of Custody is emailed or faxed to the customer for review and approval, and then the processing can begin. Before any processing is performed on samples, the proper operation of the equipment is verified by various QC/QA procedures. Even though all equipment is thoroughly cleaned between groups and companies, in order to minimize any possibility of contamination between samples, SRC assigns one processing stream for each customer.

### SIEVING SAMPLES

At this point the samples are entered into the lab's automated Laboratory Information Management System (LIMS). The following data are recorded for each group of samples: initial sample weight, and the weights for the following fractions: +1.00 mm, -1.00+0.500 mm, -0.500+0.250 mm,-0.250 mm, permroll paramags and nonmags, Lithium Heteropolytungstates (LST) and Methylene iodide (MI) sinks and Frantz upper/ lower fractions. The LIMS aids in identifying any potential sample losses or data entry errors by automatically generating a report that will indicate any loss of any material throughout the whole processing circuit, from the initial weight of the sample through to the concentrate. Samples are initially weighed using balances that are checked each day with certified weights and then transferred from the bag into a labeled pail filled with water and calgon. The sample is then agitated for approximately 2 minutes in order to deslime the samples. Then samples are wet-sieved on a Sweco circular sieve that produces several sized fractions: +1.00 mm, -1.00+0.500 mm, -0.500+0.250 mm, -0.250 mm. For every group of samples, a random sample is sieved to determine screening efficiencies. In order to meet Quality Control (QC), sieving efficiency must be e•95%. All QC data are recorded and retained for customer audits.

### HIGH INTENSITY MAGNETIC SEPARATION (PERMROLL)

The -1.00+0.500 mm and -0.500+0.250 mm fractions are dried, then permrolled. The operation of each permroll is verified at the beginning of each day or the beginning of each batch of samples by processing a spiked QC sample. The QC sample is spiked with 40 kimberlite indicator minerals derived from kimberlite concentrates. The QC sample is processed twice through each permroll. On the first pass of the permroll, the efficiency requirement is e•80% and on the second pass is 100%. Once again, these QC data are recorded for auditing purposes. The permroll (Fig.2) separates the material into a paramagnetic and a non-magnetic fraction. The paramagnetic fraction is processed through heavy liquids and the non-magnetic fraction is retained and stored along with the +1.00mm and -0.250mm material.

### HEAVY LIQUIDS AND FRANTZ MAGNETIC SEPARATOR

The initial heavy liquid utilized is LST at 2.96 specific gravity (SG). The LST floats (SG<2.96) are discarded and the LST sinks (SG>2.96) are further processed through MI at 3.23 SG or 3.3 SG. The MI floats are retained and the MI sinks are processed through the Frantz Magnetic Separator which separates the MI concentrates into two fractions based on magnetic susceptibility of the minerals. QC for the heavy liquids circuit consists of verifying the specific gravity of each liquid by using a METTLER TOLEDO Densito 30PX prior to processing each sample batch. As well, for each batch of samples, a random sample is chosen for repeat

continued on page 12

## Focus on: SRC Geoanalytical Laboratories... continued from page 11

***Figure 2**. The permroll is used to separate material into paramagnetic and non-magnetic fractions. The paramagnetic fraction is then further processed through heavy liquids prior to picking of kimberlite indicator minerals.*

reprocessing of the LST floats and MI floats. Also random audits of the heavy liquid circuit are carried out using barren till samples spiked with kimberlite indicator minerals (KIM).

**OBSERVATION**

At this point, the processing of the samples is complete and the concentrates are sent for observation and picking of KIM (Fig. 3). The size fractions for observation are typically +0.250-0.500 mm and +0.500-1.00 mm, some customers request different sizes. The species of indicator minerals picked are peridotitic pyrope, eclogitic pyrope, olivine, chrome diopside, chromite and picroilmenite (Mg-ilmenite). We also identify background minerals associated with gold and base metals for example pyrite, galena, sphalerite, molybdenite, etc. Observation QC consists of doing a second pass observation on randomly selected samples within the group, about 10% in a batch. A two-pass observation on samples is done if requested by the

***Figure 3.** The +0.250-0.500 mm and +0.500-1.00 mm heavy mineral concentrates are observed under a binocular microscope and kimberlite indicator minerals are picked and counted.*

customer. Once the observation is completed a material balance report is calculated to ensure that the MI sinks weight matches the total observed weight.

The KIM laboratory has 12 observers, one mineralogist and two senior observers who are responsible for all the second pass observations of the concentrates. The senior observers are also responsible for checking all KIM grains on the mounting cards and the final audit of the observation report. Once they have completed their audit, the reports along with the grains are then forwarded for data entry. Once the data are entered and the QC audit is completed, the report is now ready for the customer. Mineral grains are archived until further instructions are received.

SRC Geoanalytical Laboratories has an in-house scanning electron microscope (SEM) model S-3000 that aids in identification of the questionable grains. The SEM is used without carbon coating on the grains so that the grains can be used for further analyses and also teaching purposes. Most of the KIMs are then submitted for electron microprobe analyses for determination of their chemical composition. Geoanalytical Laboratories collaborates closely with the Electron Microprobe Lab, Dept. Geological Sciences, University of Saskatchewan.

Microdiamond analyses using caustic fusion are another service that SRC Geoanalytical Labs offers. An exploration drill program can produce sufficient volumes of drill core for microdiamond analyses to produce an approximate estimate the population of diamonds in a

continued on page 13

## Focus on: SRC Geoanalytical Laboratories...

continued from page 12

deposit, without taking a large more costly bulk sample. SRC Geoanalytical Labs has the highest capacity microdiamond analyses facility in the world. The lab's capacity has increased for three consecutive years to better serve the growing Canadian exploration industry, thus offering a faster turn-around. An additional 36 kilns are expected to be added by March 2007, which will bring the total to 80 kilns. At that time, the lab will be able to process 2 metric tones per week by caustic fusion. The additions will be housed in a new state-of-the-art, 60,000 square foot facility in Saskatoon. The goal of SRC Geoanalytical Labs is to provide accurate, efficient results, translating into many successful mineral exploration projects in Canada.

Due to the potential growth of the diamond industry, SRC is responding by establishing the SRC Geoanalytical Laboratories as a world-class laboratory in diamond processing. This is being achieved by broadening the spectrum of services offered which will enhance clients' exploration efforts and by building a much larger facility to handle the even higher volumes expected to be processed in the future.

**Cristiana Mircea**
*Mineral Laboratory Supervisor*
*SRC Geoanalytical Laboratories*
*15 Innovation Blvd.*
*Saskatoon, Saskatchewan,*
*CANADA S7N 2X8*
*tele: 306-933-7749*
*Email: mircea@src.sk.ca*

# Indicator Mineral Processing at SGS Minerals Services

### INTRODUCTION

The SGS Minerals Services mineral separation facility at Lakefield, Canada has a long history dating back to Lakefield Research's earliest days in the 1940s as an industrial mineral facility. The indicator mineral processing laboratory was originally developed when Lakefield Research was part of Falconbridge Ltd, to provide support for the company's many exploration programs around the world. As an independent company, the lab's clients expanded to include most diamond exploration companies. Since joining the SGS group in 2002 its services are available through the SGS global network for exploration programs worldwide.

Currently the materials processed though the facility vary widely, ranging from till and alluvial samples, to beach sand and bedrock samples. As a result there are a variety of flowsheets for different types of starting material. The basic flowsheet shown in Figure 1 is designed to recover as wide a range of indicator minerals as possible, including recovery of diamonds and gold grains.


***Figure 1**. Standard indicator mineral extraction flowsheet used at the SGS Lakefield facility – reject material at each step is dried and stored. Weights indicated are approximate and sample dependant.*

### SAMPLE PROCESSING

Typically, samples are wet screened after weighing. If geochemical analysis of the sample matrix is also required, all or part of the sample may be dried and screened to remove the –0.18 mm material to ensure recovery of the clay sized and finer material which can be critical as the host of mobile elements and a carrier of geochemical signals. Sample sizes can vary dramatically from a few hundred grams to 50-100 kg. Often samples may have been pre-screened in the field to remove +2 mm material to reduce transportation costs. An attrition mill may be used for sample disaggregation, particularly for clay rich samples that may be indurated to some degree. Rock samples (usually 5 -20 kg) submitted for indictor mineral recovery are stage crushed to passing 2 mm; stage crushing will tend to yield a higher proportion of intact mineral grains. After screening, the sample goes directly to heavy liquid separation.

Standard screen sizes for till samples are 0.85 mm and 0.25 mm. The screened -0.85+0.25 mm fraction is dried before being fed to a Wilfley table fitted with a slurry pump to re-circulate the tails. The table set up parameters can be adjusted by an experienced operator to ensure that the complete heavy mineral train is collected. If quality control (QC) tests indicate inadequate heavy mineral recovery, the table tails will be processed through a Permroll magnet to recover any remaining magnetic minerals that might normally report to the heavy mineral concentrate. The indicator mineral processing lab has access to an array of magnetic and electrostatic instruments that may be used for specific mineral separation processes.

The heavy mineral portion may then be acid washed prior to drying and processing in methylene iodide diluted to a specific gravity (SG) of 3.1. Tetrabromo-ethane may be used if a lower specific gravity is preferred. After removal of ferromagnetic minerals with a hand magnet, the concentrate is divided into two fractions by screening at 0.5 mm. If the concentrate is

continued on page 14

## Focus on: SGS Minerals Services...

continued from page 13

large, 30 g will be riffled out to speed processing. The remainder is processed at client request or if the indicator mineral content is low. A Frantz magnetic separator divides the sample into paramagnetic and non-magnetic mineral fractions for the picking lab. This separation helps indicator mineral picking as ilmenite and chromite will be concentrated in the paramagnetic portion while the non-magnetic portion (also containing weakly paramagnetic grains) will contain garnet, chrome diopside, olivine and other silicates. At each stage of the process reject portions of the sample are dried, weighed and stored.

**INDICATOR MINERAL SELECTION**

The picking lab uses high quality stereo microscopes with a variable 10 to 50 times zoom lens and daylight halogen fibre optic light sources. Questionable grains can be checked by a scanning electron microscope (SEM) equipped with an energy dispersive system (EDS). An automated x-ray diffraction system is also available. While recovery of the full suite of kimberlite indicator minerals including diamond constitutes the bulk of the workload, our mineralogists have worked on projects that require recovery of a variety of minerals, including base metal indicators, gold grains for morphological study, zircons for mineral provenance studies, tourmaline from lamproites and rutile from gold deposits. Occasionally some of these studies will require processing of fractions >0.85 mm or <0.25 mm. Gold and PGE minerals can be concentrated by using a Superpanner to process silt sized (<0.063 mm) fractions.

Description of kimberlite indicator mineral surface textures is also part of the services offered. Descriptive parameters include mineral type, form, shape, luster, clarity, surface texture and the degree of corrosion for chromites. Surface texture reports may be augmented by digital SEM images or photomicrographs.

**QA/QC**

The indicator mineral extraction process at SGS Minerals Services is among the procedures that is ISO 17025 certified by the Standards Council of Canada. Quality Assurance procedures include standard operating procedures for all aspects of the process and training and monitoring of staff. ONLINE LIMS is used for detailed worksheets, batch and sample tracking including weights and labeling for all the products from each sample. Quality control procedures include:

- Sample spiking with synthetic diamond SG 3.52
- Table tails audit with heavy liquids to verify complete heavy mineral recovery
- Balance and screen calibrations
- Quality control repicking of 50% of samples
- Checking of picked indicator minerals by a mineralogist
- SEM-EDS checking of questionable grains (generally ilmenite).

**ELECTRON MICROPROBE ANALYSIS**

Indicator mineral chemistry is determined with a JEOL 733 Superprobe (one energy & four wavelength dispersive spectrometers with PET, LiF, TAP, DLE crystals) that has calibrations specifically for diamond indicator minerals. Calibrations are based on well known standards (e.g. from the Smithsonian & SPI) from a wide range of natural and synthetic minerals. Typically, it is recommended that 50-100 grains of key indicator minerals are analyzed per sampled lithology. The SGS Minerals Services facility has a fully equipped section preparation lab on site for the preparation of high quality polished and thin sections for microbeam analysis and optical study in both reflected and transmitted light. Grain selection procedures include backscattered electron (BSE) imaging of altered diamond indicator minerals grains to analyze the non-altered core parts of chromite and ilmenite grains relevant to diamond forming conditions.

Frequent quality control (QC) checks (up to 30% of the analytical run) carried out as part of the routine electron microprobe analytical protocol include: 1) silicate and oxide check standards similar in composition to the diamond indicator minerals, 2) blank checks (such as Na in synthetic rutile) and 3) duplicate grain analysis in a second run. Other quality assurance (QA) checks include measurements of some elements by two different spectrometers and wavelength dispersive crystals with a comparative analysis to identify systematic errors. Previously analyzed minerals may also be used as QC checks; compositions are verified at other microprobe facilities. We participate in the Open University GeoPT round robin for microprobe labs. Laser ablation ICP-MS analysis for some mineralogy projects is performed at the Memorial University of Newfoundland (MUN) facility.

Interpretation of mineral chemistry has been carried out for a number of projects including thermobarometric calculations using the single pyroxene method and the Ni in garnet method. For bedrock samples, these interpretations will usually be accompanied by a petrographic study using standard optical methods as well as SEM BSE imagery for detailed characterization of groundmass minerals and textures.

**MICRODIAMOND EVALUATION**

The SGS Mineral Services Diamond group has a large caustic fusion laboratory for microdiamond extraction and characterization. Developed in support of the Falconbridge Ltd diamond exploration programs, it was the first caustic fusion lab developed for this purpose. Microdiamond recovery by caustic fusion is now a key part of the process for diamond exploration. Minimum recommended sample sizes are 24 kg per specific lithological unit. Sample aliquots of 5 - 8 kg in size are dissolved in molten caustic soda in stainless steel fusion pots heated in kilns to 500-600$^{o}$ C. The molten mix is poured onto 0.105 mm screens and the residue is then washed and treated with acids leaving a small concentrate which is picked for diamonds. Microdiamond counts and weights are reported for each size class using a root-two

continued on page 15

## Focus on: SGS Minerals Services...

continued from page 14

progression of square mesh sieve sizes from 0.105 mm up in accordance with the CIM guidelines. Individual stones are measured (X,Y,Z dimensions), and described in terms of colour, clarity, percentage preservation and stone morphology. Key quality control procedures consist of spiking samples with synthetic diamonds and duplicate picking of the sample residues. Recovery of kimberlite indicator minerals from the caustic fusion residues is carried out on occasion for some clients. The caustic fusion attack does not completely dissolve many refractory minerals such as picro-ilmenite, chromite, garnet, zircon and corundum and these may be picked for further study.

**CONCLUSION**

The indicator mineral lab is part of a larger SGS Minerals Services mineralogy group at the Lakefield facility with expertise in most mineral commodities and their mineralogy. A full range of services is available for diamond exploration programs as well as for other commodities. Additionally there is access to the SGS analytical geochemistry laboratories for major and trace element analysis using state of the art instrumentation.

On a larger scale for mini-bulk samples, the facility has a dense media separation (DMS) plant with 1 t/hour and 10 t/hour units. These are used mainly for macro diamond extraction with a bottom screen size of 0.85 mm or occasionally 0.5 mm. Other projects include extraction of gemstones such as ruby, sapphire or emerald.

Studies of gold and PGE minerals form a major part of the project load of the mineralogy group now housed in SGS Minerals Services' Advanced Mineralogy Facility. This facility is centred around quantitative mineralogical studies based on QEMSCAN technology using an automated SEM with BSE imaging and x-ray mapping controlled by a highly sophisticated image analysis software suite. This technology holds considerable promise for bulk indicator mineral studies and automated kimberlite textural characterization for geo-metallurgical mapping.

While the Lakefield Canada facility has the widest range of mineralogical services to offer, other SGS Minerals laboratories around the world have some of the mineralogical laboratory capabilities described here. The most significant of these is the facility in Johannesburg, South Africa.

**Hugh de Souza**
*Manager Diamond Exploration Services*
*SGS Minerals Services*
*PO Box 4300, 185 Concession Street*
*Lakefield, ON, CANADA K0L 2H0*
*tele: 705-652-2112*
*Email: hugh.desouza@sgs.com*

## Heavy Mineral Processing at Vancouver Indicator Processors Inc/ Teck Cominco Global Discovery Lab

**INTRODUCTION**

Vancouver Indicator Processors Inc ("VIPI") specialize in extracting heavy mineral concentrates from till samples for "kimberlite indicator minerals" such as pyrope, ilmenite, chromite, olivine, and chrome diopside in support of diamond exploration. The company, located in Vancouver, Canada, was formed in 2002 to provide an indicator mineral processing service to the diamond exploration industry, and is in its 5th year of operation. VIPI's process is a co-operative venture with Teck Cominco's Global Discovery Labs ("GDLabs"), also located in Vancouver, since an essential part of the concentration is performed in GDLabs heavy liquid section, which has been in operation for over 30 years.

Published case histories of diamond exploration demonstrate that the use of indicator minerals to locate kimberlites is a remarkably powerful technique. Indicator minerals may point to the presence up-stream, up-wind, or up-ice of a kimberlite or kimberlite cluster; features on the indicator mineral surfaces can suggest how close the source is; microprobe analysis of indicator grains provide information on the diamond potential of the undiscovered kimberlite; and subsequent till sampling may pinpoint the location of a kimberlite a few kilometres to many tens of kilometres away from the discovery sample.

Detection limits for indicator minerals are low, for example recovery of a few high -Cr, low- Ca pyropes 0.5 mm in diameter from a 25 kg till is equivalent to a concentration of about 50 ppb, and this can be significant. The indicator mineral method, with various adaptations, has proven useful in diamond exploration in environments as diverse as the Kalahari Desert of Botswana and the glaciated terrain of northern Canada.

**PROCESSING PROCEDURES**

Heavy minerals are concentrated at VIPI and GDLabs as shown in Figure 1. These procedures may be varied due to the nature of the sample, or at a client's request. For example, different screen sizes may be requested, fractions that are normally discarded can be retained for observation or further processed. For example, the nonmagnetic fraction might be processed for gold. Samples are typically tills up to 25 kg, but field-screened tills, screened or unscreened stream sediments, eolian sand, soils, lake- bottom sediments, and crushed kimberlite or other rocks can be processed. VIPI's lab equipment can accomodate samples up to about 45 kg, and larger samples can be processed in batches.

Samples are weighed as-received and given a unique consecutive number. They are first disaggregated and deslimed in a concrete mixer, followed by wet- screening. A paramagnetic concentrate is made from the dried –0.86+0.25 mm fraction using a high-intensity magnet.

continued on page 16

## Focus on: Vancouver Indicator Processors... continued from page 15

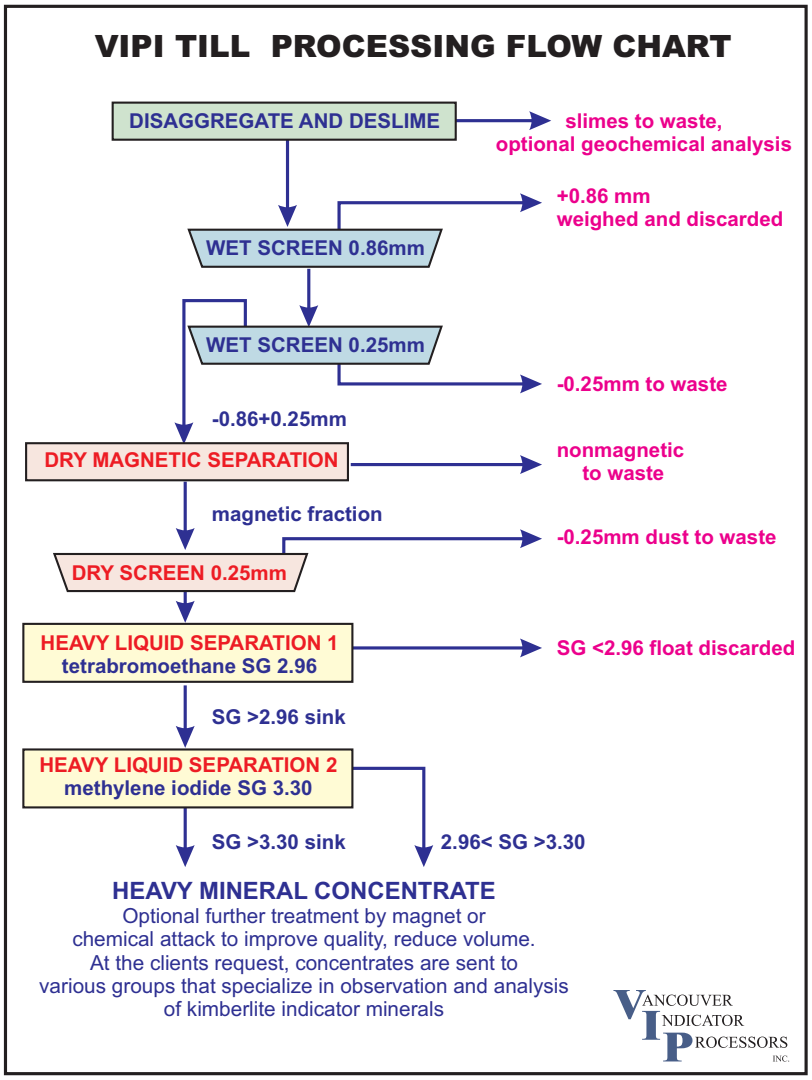



***Figure 1.*** *Flow chart for till sample processing at VIPI and GDLabs.*

This paramagnetic concentrate is then processed through organic heavy liquids to extract a heavy mineral concentrate. The -0.86+0.25 mm size fraction is most suitable for kimberlite indicator mineral observation as it contains a range of sizes from coarse to medium sand. Kimberlite indicators are usually most abundant in the finer grain sizes, but material -0.25 mm is tedious and expensive to examine, although it can be done if required. For example, where few indicators are present , such as in areas of Paleozoic carbonate terranes in northern Canada, it may be better to produce a concentrate as fine as 0.15 mm rather than collect a much larger sample to obtain an acceptable volume of +0.25 mm concentrate.

Separation processes work best on closely sized material, but our tests show the spread in grain-size from 0.86 to 0.25 mm does not measurably reduce the recovery of indicator minerals. Observers may not routinely look at the coarser part of the concentrate (-0.86 to 0.5 mm), but it is immediately available if numerous indicators are found in finer sizes. For example, abrasion and primary surface features that may be present on coarser particles can indicate proximity of the kimberlite source. Some details of each step of the processing procedure are described below and outlined in Figure 1.

**Wet screening** is carried out on double-deck, 30 inch diameter vibrating screens manufactured by *Kason Corporation*. Standard stainless steel screens used have square openings of 0.86 mm and 0.25mm , but 4 mm, 2 mm, 0.5 mm and 0.15 mm sizes are also available. The –0.86+0.25 mm fraction is dried, weighed and retained. All other fractions are weighed and routinely discarded, but any fraction can be retained at the client's request.

**Magnetic separation** is performed with a permanent Fe-Nd dry belt magnetic separator manufactured by *Outokumpu Technology Inc* and operating at 2.1 Tesla. This magnet splits the sample into 3 fractions, (1) non-magnetic/ diamagnetic, (2) weakly paramagnetic, and (3) strongly paramagnetic. The main kimberlite indicator minerals are paramagnetic, and the non-magnetic/diamagnetic fraction consists mainly quartz and feldspar. The weak (2) and strong (3) paramagnetic fractions are combined in one "magnetic concentrate". Before this magnetic concentrate is passed on for further concentration of heavy minerals using heavy liquids it is screened to remove any <0.25 mm particles that may have become dislodged during drying or were produced by drying. If diamonds, gold or other non-magnetic minerals are of interest the non-magnetic fraction may be retained and processed to recover these, but otherwise it is discarded.

**Heavy liquid processing**, typically on material up to 1 kg, but sometimes more, is carried out at GDLabs using a 2-stage process. The heavy sink from tetrabromoethane ("TBE") a liquid of 2.96 specific gravity ("SG") is further separated in methylene iodide ("MI") of SG 3.30 to produce a concentrate > SG 3.30 and a float between 3.3 and 2.96 SG. The SG >3.3 sink will contain pyrope (SG 3.6-3.9), ilmenite (SG 4.7-4.8) and chromite (SG~5.1) , while olivine (SG 3.2-3.5) and chrome diopside (SG 3.2-3.6) may report to either or both the >3.3 SG or the 2.96 to 3.3 SG fractions. At a client's request heavy liquids are sometimes diluted with solvent to SG's lower than listed above.

Concentrates can be further processed at the client's request with the objective of reducing their volume or removing a mineral that makes observation difficult. For example, chemical attack may greatly reduce the volume of iron oxides, often by as much as 90%. Magnetic processing can also remove amphiboles, pyroxenes, or crustal garnets. Such methods can reduce overly large concentrates from hundreds of grams to tens of grams or less.

Heavy concentrates (SG >3.30) and floats (SG 2.96 to 3.30) are sent to various independent groups for microscopic examination and electron microprobe

continued on page 17

## Focus on: Vancouver Indicator Processors... continued from page 16

analysis. VIPI maintains a close association with KIM Dynamics Inc., an indicator mineral observing lab in North Vancouver, Canada, and the majority of our concentrates are examined microscopically by them. However, at a client's request concentrates can be sent to observing labs in Canada, USA, Australia, and South Africa. Observation is the slowest step in the indicator mineral survey process and it is sometimes helpful to send concentrates to several observing labs to speed the process.

To maintain a "chain of custody" all concentrates and materials that leave the VIPI's lab are transported to and from GDLabs and to KIM Dynamics by our staff if in Vancouver, and international courier if outside Canada. The cost to send batches of 50 to 100 small concentrates to observers in the USA or Australia is generally less than $1 per sample, and transit time is only a few days.

**CHOICE OF METHODS**

Laboratories that concentrate heavy minerals use many different devices and processes, including various types of magnets, tables, dense media separators, and organic and inorganic heavy liquids. This variety contrasts with commercial geochemical labs where there is more similarity in types of analytical equipment and procedures, in qualifications required by the analyst, and where national or international standards are widely used and results of analyzing them routinely reported.

Our process is essentially based on the excellent density separation achieved by traditional organic heavy liquids. The main reason for using 2 stages of heavy liquid separation is that MI, the most useful heavy liquid, is about 7 times more expensive than TBE. The function of magnetic separation, which precedes heavy liquid processing, is to reduce the volume of cleaned, sized sand prior to the heavy liquid separation (usually on <1 kg ). Tests show nearly 100% of the indicators pyrope, chrome diopside, ilmenite, chromite, and olivine can be recovered in the combined strongly paramagnetic and weakly paramagnetic fractions from the high-intensity permanent magnet.

VIPI does not observe concentrates, and there are advantages to separating the functions of concentration and observation. One is security of information for the client, as only independent observers know what is in any client's concentrates, while our partner GDLabs need not know even the identity of the client. Another advantage is the freedom to send concentrates to observers of the client's choice, or to speed up this process.

**QUALITY CONTROL**

One aspect of quality control is to use devices that do not vary in their operation, and do not need operators with a special "touch". This is the reason VIPI prefers the permanent magnet over a more versatile but perhaps less consistent electromagnet. Another aspect that affects quality control is the inherent cleanliness of equipment. It is desirable to have easily cleaned smooth surfaces in contact with samples, with no crevices than can trap grains and subsequently release them into a later sample. The concrete mixers, magnet and heavy liquid funnels used in our process are such easily cleaned devices. For screens, in which grains close to the aperture size inevitably lodge, scrubbing and pressure washing must be used. The sharp density separation achieved by TBE and MI heavy liquids is well known and requires little testing to confirm. However, it is important to maintain the SG of the heavy liquids by daily testing with a float-type densitometer.

To frequently test the recovery of indicators in client's samples through the entire flow-sheet requires spiking, which presents some difficulties. Small plastic cubes of known density can be used as tracers, but in our process they would not be recovered in the magnetic concentrate. Samples can also be spiked with actual kimberlite indicators that are distinctive or marked in some way, but there is a risk they may break up and not be recognized as spikes. Some of these problems can be avoided by spiking samples other than client's samples. Non-kimberlitic minerals of similar density and paramagnetic response to kimberlite indicators can also be used as tracers.

While it is reasonable for labs to monitor their own performance, the results would be more convincing if done independently. Ideally, a nationally-recognized standard spiked till would be introduced anonymously into the sample stream by the client, the spikes counted by a third disinterested party, and results made available to both client and lab. Such a procedure is not available at present.

Averill and Huneault (2003) described the procedures used at Overburden Drilling Management Ltd, which essentially involves a thorough annual test of their entire process by inserting known numbers of the common indicators into a small number of natural till samples that had already been processed, proved barren, and reassembled. VIPI has followed a similar approach, using a "base" sample that consists of coarse (+0.86mm ) material from previously processed tills, fine slimes (<<0.25 mm) also from previously processed till, and for the material in between these sizes we use screened and magnetically cleaned white quartz sand ("Lane Mt" sand) of -0.86 +0.25 mm. This synthetic sample resembles a natural till in its range of grain sizes and weight proportions of each size fraction (slimes, fines, sand, gravel). To each of 4 samples of ~15 kg of the base sample are added 60 indicator minerals of 6 mineral species from 0.86 to 0.6 mm and 50 grains of 6 indicator mineral species sized from 0.5 to 0.4 mm. The indicator minerals are all from kimberlite, except for chromite which was derived from the Stillwater Ultramafic. These indicator mineral spikes were screened to size and chosen for their sturdy, mostly equant shapes, lack of cleavages, etc. Spiked samples are processed in the normal way through the entire flow sheet, and the final heavy concentrates examined. Four tests over the past 3 years gave overall recoveries of the indicator mineral spikes from 82 to 95%

continued on page 18

## Focus on: Vancouver Indicator Processors...

continued from page 17

for the coarse size and 84 to 95% for the fine size, averaging 91% for each size. Some details of the most recent test are shown in Table 1, which shows some typical variability in behaviour of the different indicators due to magnetic and density characteristics. Reasons for non recovery of grains include the lodging of grains in screens or mixers, breakup of indicators, which is sometimes recognized by finding small splinters of indicators in concentrates, and loss to the nonmagnetic fraction or to TBE floats. Recovery and contamination are obviously linked together, since any grain that is lost may contaminate the next sample if it remains in a screen or mixer. Even if tests show a fairly high recovery of indicators is possible this is still a matter of concern.

The quality control procedure described above is time-consuming and unfortunately cannot be done frequently. However, it appears to be a fairly good test of the whole process, and should be valid so long as equipment or procedures are not changed. Keeping operator influence to a minimum and maintaining consistency of procedures are essential if it is to have any long-term relevance as a measure of recovery.

**REFERENCE**

Averill, S. and Huneault, R. 2003. Controlling the quality of kimberlite indicator mineral processing using indicator mineral spikes. **EXPLORE**, No. 119, p. 1-4 and 19-21.

**Peter Le Couteur**
*VIPI Laboratory*
*Unit 101, 6200 Darnley St,*
*Burnaby, BC, CANADA V5B 3B1*
*Tel (604) 294-9011, fax (604) 294-9022*
*Email vipi@telus.net*

**Jim McLeod**
*Teck Cominco Global Discovery Labs*
*1486 East Pender St,*
*Vancouver, BC, CANADA V5L 1V8*
*Tel (604) 685-3034*
*Email jim.mcleod@teckcominco.com*

| Indicator mineral | Total grains | Recovered in mag con | Grains in nonmag | Grains lost | Recovery in mag con as % |
|---|---|---|---|---|---|
| **Coarse size (-0.86+0.6 mm)** | | | | | |
| Eclogitic pyrope | 20 | 18 | | 2 | 90% |
| Peridotitic pyrope | 20 | 20 | | | 100% |
| Fused eclogitic pyrope | 20 | 20 | | | 100% |
| Fused peridotitic pyrope | 20 | 20 | | | 100% |
| Olivine in MI sink | 40 | 36 | | | 90% |
| Olivine in MI float | | 4 | | | 10% |
| Chrome diopside in MI sink | 40 | 1 | | | 3% |
| Chrome diopside in MI float | | 32 | 3 | 4 | 80% |
| Ilmenite | 40 | 40 | | | 100% |
| Chromite | 40 | 37 | | 3 | 93% |
| **Totals** | **240** | **228** | **3** | **9** | **95%** |
| **Fine size (-0.5+0.4 mm)** | | | | | |
| Eclogitic pyrope | 20 | 19 | | 1 | 95% |
| Peridotitic pyrope | 20 | 20 | | | 100% |
| Olivine in MI sink | 40 | 21 | | | 53% |
| Olivine in MI float | | 13 | 1 | 5 | 33% |
| Chrome diopside in MI sink | 40 | 3 | | | 8% |
| Chrome diopside in MI float | | 36 | | 1 | 90% |
| Ilmenite | 40 | 39 | 1 | | 98% |
| Chromite | 40 | 39 | | 1 | 98% |
| **Totals** | **200** | **190** | **2** | **8** | **95%** |

**Table 1** Results of a test of recovery of kimberlite indicator minerals added to four ~15 kg samples in August 2006. To each sample were added 5 grains (total 20 grains) or 10 grains (total 40 grains) of each indicator mineral species. The "mag con" is the combined weakly and strongly paramagnetic fractions, and indicators were recovered from methylene iodide ("MI", SG= 3.3) heavy liquid concentrates (both float and sink).

# Extraction of Kimberlitic Indicator Minerals at KIM Dynamics Inc laboratory

## INTRODUCTION

KIM Dynamics Inc. observes and interprets kimberlite indicator minerals (KIM) in heavy mineral concentrates for numerous clients engaged in diamond exploration. The company is located in North Vancouver and has operated for 6 years. The owner of the laboratory, Maja Kiridzija M. Sc., is an exploration mineralogist/ geologist with over 12 years experience in diamond exploration especially the visual identification of KIM and interpretation of their surface textures. The combination of laboratory expertise and exploration experience allows the company to offer an integrated laboratory and consulting service.

KIM Dynamics Inc. offers the following laboratory and consulting services to diamond explorers:

- Visual identification and extraction of KIM grains from sample concentrates
- Description of KIM colors, morphological and abrasion characteristics
- Determination of the background minerals in sample concentrates
- Extraction of diamonds from kimberlite concentrates
- Interpretation of the KIM geochemistry

One of the most important diamond exploration services is the visual identification of KIM grains from sample concentrates. Although it requires only a binocular microscope and a skilled observer this powerful technique has proven a very effective method of exploring for kimberlites. Therefore, this article describes procedure used at KIM Dynamics for picking KIM from till and rock concentrates.

## VISUAL IDENTIFICATION AND EXTRACTION OF KIM GRAINS FROM SAMPLE CONCENTRATES

The extraction of KIMs from concentrates of till or rock samples consists of standard and optional procedures. Standard procedures include receiving, screening, observing mineral concentrates and quality control of KIM observation. Concentrates of till or bedrock samples arrive from processing laboratories to KIM Dynamics Inc. in vials, plastic bags or other containers. Before observation, concentrates are always screened into several size fractions in order to improve efficiency of observation. Recommendation for microprobe or SEM grain analyses may be given to the client in the written report. The results of the standard quality control of the KIM observation are also submitted to the client as part of the report.

Optional procedures include splitting and/or washing the concentrate. Splitting of the concentrate is done to reduce the weight for observation by one half or one quarter in order to reduce observing time. Washing the concentrate involves ultrasonic cleaning of mineral grains to assist visual identification.

Most of the samples concentrates that arrive in KIM Dynamics Inc. for KIM observation are in the size fraction from 0.25 mm to 0.5 mm. However, it is a standard procedure at KIM Dynamics Inc. to screen each concentrate into five size fractions, “>0.5 mm”, “0.5-0.4 mm”, “0.4-0.3 mm”, “0.3-0.25 mm” and “<0.25 mm + HM” (Fig. 1) before KIM observation under the binocular microscope. This process is needed to remove dust (<0.25 mm) and to sort mineral grains into same size ranges for the sake of easier focusing and recognition of minerals. At the same time the strongly ferromagnetic minerals (HM) are removed using hand magnet and set aside. The size fractions +0.5 mm, +0.4 mm, +0.3 mm and +0.25 mm are observed under the binocular microscope separately. The “HM + <0.25 mm” fraction is not observed.

***Figure 1.*** *Screening samples into different size fractions before KIM observation.*

Observation and extraction of KIMs are time consuming and require a binocular microscope and highly skilled observers. Leica and Kyowa binocular microscopes with Volpi light sources are used to examine the concentrates. KIM Dynamics Inc. has a team of 9 mineral observers internally trained for the recognition of KIM and background mineral grains. Detailed information about the observation of each sample is recorded in a data sheet as shown below. Sample sheets contain data on sample number, date of observation, name of observers, concentrate size weights for all 5 screened portions, recovered number of indicators in each size fraction and total number of indicators recovered and comments. Comments may include details on the estimation of indicator numbers, recommendation for further work to check possible indicator minerals for verification, the background mineralogy or the presence of unusual minerals etc.

continued on page 20

## Focus on: KIM Dynamics Inc. ...

continued from page 19

*Table 1. Example of data recording sheet used per each sample examined by KIM Dynamics.*

| Sample Number |
|---|
| |

Observed by ***KIM Dynamics Inc.***
Date of observation _____
Observing time _____
Observer initials _____

| *Size fraction (mm)* | *+0.5* | *+0.4* | *+0.3* | *+0.25* | *HM + <0.25 mm* | *TOTAL OBSERVING* |
|---|---|---|---|---|---|---|
| **Weight (g)** | | | | | | |
| **Peridotitic garnet** | | | | | | |
| **Eclogitic garnet** | | | | | | |
| **Picroilmenite** | | | | | | |
| **Chromite** | | | | | | |
| **Chrome diopside** | | | | | | |
| **Olivine** | | | | | | |
| ***TOTAL*** | | | | | **N/O** | |

Comments _____

The following KIMs are observed by KIM Dynamics: peridotitic garnet, eclogitic garnet, picroilmenite, chromite, olivine and chrome-diopside (Fig. 2). Possible kimberlitic indicators are discussed in the comments section of the data recording sheet. Recommendations for additional analyses are given in the comments or in a separate written report.

***Figure 2****. Color photograph of kimberlitic indicator mineral species that are picked from concentrates at KIM Dynamics: purple-orange peridotitic and eclogitic garnet; green chrome diopside; black (left) chromite; pale yellow olivine with clear diamond in the middle; and black (right) picroilmenite.*

During KIM observation, concentrates are spread out one grain thick in a petri dish. It is important that grains are not overlapping so that each grain is entirely exposed for visual examination. Different techniques are used in order to methodically observe every grain in concentrate (Fig. 3). Which of the observing techniques, "spiral",

***Figure 3.*** *Different techniques for concentrate observation and picking used at KIM Dynamics: a) spiral; b) lines; c) quadrilles.*

continued on page 21

## Focus on: KIM Dynamics Inc. ...

continued from page 20


"lines" or "quadrilles, " used at KIM Dynamics depends on the observer's preference. Any grain that may resemble KIM is picked ("if you doubt pick it out"). Extracted grains are placed on a sticky tape in punched cardboard. After examination of the entire concentrate, an observer verifies all extracted grains and indicates all possible KIM found. Each possible KIM grain is checked by a KIM Dynamics mineralogist and a final decision made on the number of definite and/or possible KIM picked from the concentrate. SEM and electron microprobe analyses are not required at this point of time.

**QUALITY CONTROL**

Quality control is monitored by spiking and by double-pass observation. Ten percent of a client's samples is spiked. A KIM Dynamics mineralogist does the spiking of the concentrates after screening but before observation. The spikes could be any of the KIM species, peridotitic/eclogitic garnet, chromite, picroilmenite, chrome diopside or olivine. They are examined, well described and sketched before spiking. The number of spiked grains in the sample varies from 1 to 10. The record of spiking grains and spiked samples are kept in a file until sample observation is finished. If the observer does not recover the spiked grains the mineralogist recovers the spikes in a second observation. If spiked grains could not be found after significant amount of time a note with brief explanation is put in the concentrate container and in the spiking report.

Ten percent of concentrates are observed twice ("double–pass"). The samples observed twice are chosen randomly and a different observer than the first pass observer does the second pass observation. The "double pass" observation is considered necessary in highly positive concentrates (> 50 KIM) where numbers of KIM grains may be recovered in the second, even in third observation pass. Spiking and double-pass observation results are included in the report on procedure and results and always provided to the client.

**REPORTING ON RESULTS**

The complete client report consists of a KIM results table and report on the procedure and results. These documents are put into a binder together with sample sheets and plastic folder containing mineral cards with collected KIM. The KIM results table lists the number of collected KIMs in each sample concentrate, observing weights and time spent on observation.

The report prepared for clients includes a description of procedures used in preparing concentrates before observation such as screening or washing and interpretation of KIM results such as colors, morphology or surface features of picked grains, the background mineralogy and quality control results. The report provides all information on concentrate treatment in KIM Dynamics from the arrival to the departure. It consists of introductory part, procedure, results and quality control.

The introductory part of the report includes: date of arrival, number of concentrates arrived, who delivered

continued on page 22

## Focus on: KIM Dynamics Inc. ...

continued from page 21

*Table 2. Example of KIM results provided to clients by KIM Dynamics*

| Client # | Weight (g) | | KIM | | | | | | | Obs Initials | Hours spent on picking (h) | Background mineralogy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Picked (>0.25mm) | Not picked (HM +<0.25mm) | Peridotitic garnet | Eclogitic garnet | Picro-ilmenite | Chromite | Chrome diopside | Olivine | Total | | | |
| **33671** | 6.8 | 1.9 | **4** | | **1** | **3** | | **2** | **10** | SH | 3.2 | *pyroxene, r. fragments* |
| **33672** | 4.2 | 2.9 | **5** | **2** | | **4** | | | **11** | PT | 2.0 | *hematite* |
| **33673** | 3.2 | 1.7 | | | | **3** | **1** | | **4** | PT | 1.5 | *limonite, hematite* |
| **33674** | 11.1 | 2.5 | **3** | **1** | **7** | **23** | | **4** | **38** | OR | 5.2 | *staurolite, almandine* |
| **33675** | 4.1 | 3.4 | | | | **4** | | | **4** | ZM | 2.0 | *almandine* |
| **33676** | 5.7 | 4.0 | | | **3** | **2** | | **5** | **10** | ZM | 2.6 | *staurolite, almandine* |
| **33677** | 2.6 | 1.5 | **1** | | | **4** | **2** | | **7** | SH | 1.0 | *hematite* |
| **33678** | 0.4 | 0.5 | | | **8** | | | | **8** | PT | 0.5 | *limonite, hematite* |
| **33679** | 6.0 | 3.2 | | | | **1** | | | **1** | PT | 3.0 | *staurolite, almandine* |
| **33680** | 1.6 | 0.9 | **3** | | | **1** | | | **4** | OR | 1.2 | *r. fragments* |
| TOTALS | **45.7** | **22.5** | **16** | **3** | **16 +3** | **41 +3** | **3** | **11** | **97** | | **22.2** | |
| | Notes | **1** | blue indicates possible KIM (requires testing) | | | | | | | | | |
| | | | double observed sample | | | | | | | | | |

them and where they are from. The procedure part of the report includes: how many mesh sizes have been used during screening, comments on their weights and any irregularities, use of optional procedures such as washing or splitting and where picked KIM grains have been stored (in KIM Dynamic's office or returned to the client). The results part of the report contains information on total weight observed, total numbers of KIM grains recovered, description of individual KIM (as visual description of all collected peridotitic garnets) and background mineralogy with comments on interesting minerals or significant amounts of rare/unusual minerals (sphene, galena, sphalerite, etc.). The description of extracted KIM grains includes shape (rounded, subrounded, angular, "shards", fractured, etc.), color (purple, reddish, pink-purple, etc) and surface features (as resorption, kelephytic rim, orange peel, etching, coatings, coarse surfaces, etc). Comments on proximity to the kimberlitic source may also be included. If chromites, olivine or chrome diopside display non-kimberlitic features (e.g. twinning, inclusions, pale color, etc.) the conclusions as to their origin will be mentioned in this part of the report. Recommendations for the SEM or electron microprobe analyses will be made if the origin of a grain (often eclogitic garnet) is inconclusive based on the morphology. The quality control part of the report includes: the number of samples have been spiked or double-observed, the number of KIMs recovered in the first and second observation pass, initials of observers who performed first and second observation pass, which KIM grains were missed and total recovery rate for that batch of concentrates. The table with details for each sample that passed double observation pass or spiking is attached in this part of the report.

The KIM results table, report, observed concentrates, sample sheets and collected KIM grains are delivered to the client personally if in Vancouver or mailed via Express post. The KIM results table and report are e-mailed to the client on their request. All results are confidential and discussed only on the client's request.

**Maja Kiridzija**
*Mineralogist*
*KIM Dynamics Inc.*
*802-121 W. 15th Street N.*
*Vancouver, B.C., CANADA V7M 1R8*
*Tele: 604 980 7853 Fax: 604 980 7851*
*Email: kdynamics@shaw.ca*

## President's Message


*Rob Bowell*

This month sees the publication of a survey by the UK government on the level of funding and success of Research and Development in various global industries. The results reveal an interesting story. Out of 1250 global companies the most significant funding for Research and Development is in hardware technology and equipment with over US $83 billion committed in 2005 to 2006 tax year in this sector alone. Despite this huge investment, predicted returns in the same year were <1% and the research budget was more or less the same as the previous year. The next biggest investor in Research and Development was, not unsurprisingly, the pharmaceutical and biotechnology industry increased research funding by 26 % to a little over US$79 billion and made a return on investment of little over 20 %. By comparison, mining was ranked number 26 (out of 26 industries). Less than $300 million was committed to Research and Development in 2005 to 2006 tax year. This was more than 130 % increase against levels of investment in 2001-2002 tax years. Despite this small investment, the return on investment globally was more than 100 % (DTI, www.innovation.gov.uk).

In the hardware and electronics technology sector and in the pharmaceutical industry, commercial advantage for a research idea lasts no longer than seven years, the life of a patent and even then it is possible for competitors to circumvent the legal mine field of patents. By comparison the location of a new mine or mineral district can provide a company an investment that lasts several decades and yields orders of magnitude greater reward for the investment. Clearly the focus on research and development in our industry needs to be reviewed if we are to address the predicted shortage in metal stocks and energy raw materials.

As a scientific association, AAG seeks in its own small way to invest in the future of applied geochemistry through publication of research in GEEA and providing a platform for discussion of research at our biennial symposium. However funding is often a limitation, particularly for younger scientists, so to this end we have been working for last year to develop a fund to promote and support research in applied geochemistry. The fund has been named the Distinguished Geochemists Fund and initially honours Alan Coope, Paul Theobauld and Paul Taufen. It is intended that in the future further geochemists that have made a profound contribution to applied geochemistry will also be honoured by the fund. It is hoped that in supporting the scientists of the future they and we will be cognisant of the lasting contribution of those who have gone before us in this scientific field. Contributions can be made through the AAG office and marked Distinguished Geochemists Fund. Currently we are assembling an international committee to oversee the distribution of the funds and organizing an administrative board in Canada to fulfil legal obligations. Please consider supporting this endeavour that both ensures a healthy future for applied geochemistry whilst being a mark of respect for those who came before us.

In a similar vein by now you should have received the second circular for the June 2007 23rd International Applied Geochemistry Symposium in Oviedo, Spain. Jorge Loredo and his organizing committee are well advanced in making preparations for this event. Please consider attending and submitting an abstract for oral or poster presentation. We are looking for industry case studies as much as ground breaking research. The technical program is varied and already several world class speakers have been signed up to present. An interesting array of field trips to mines both ancient and modern have been arranged. Spain has a long and distinguished mining history that stretches back over 6000 years.

Once again I end my column with a plea please submit your articles to GEEA and **EXPLORE** — both Gwendy and Beth are always on the look out for interesting high quality technical articles to enrich our publications. As of 2007, we will be participating in the multi-organization newsletter, *Elements*, at no additional cost to your membership. David Lentz has agreed to be our liaison with *Elements* and he too will soon be looking for material to publish on the association's pages in elements. Finally may I take this opportunity to wish you all a very happy and peaceful Christmas and a prosperous New Year and I look forward to meeting you in Oviedo in 2007!

**Rob Bowell,** *President AAG*

## Job Opportunities

### Surficial Geochemist

The Geological Survey of Canada (Natural Resources Canada) is currently advertizing the position of Surficial Geochemist, to be based in Ottawa, Canada. The salary range for the position is: $46,025 to $105,480 and the closing date for submitting applications is December 21, 2006.

Requirements for the job include:

- Doctoral degree (Ph.D) in Earth Sciences from a recognized university, with specialization in surficial geochemistry.
- Experience in conducting surficial geochemical surveys and case studies in glaciated terrain.
- Experience in planning, conducting and supervising field logistics and personnel.
- Experience as senior author of published and unpublished reports and papers covering research in surficial geochemistry and mineral deposits for recognized scientific journals.

Details about the application process and more specific qualifications are listed on the Public Service of Canada Website: https://psjobs-emploisfp.psc-cfp.gc.ca/psr/applicant/applicant.helpcareerchoices;PsrSessionID=FjxjjmPkW3mDJsDtTxThZV2bXpgh!1612613873?action=applicant.helpcareerchoices&lang=en&psrsMode=1&poster=15360

# Job Opportunities

LaurentianUniversity
UniversitéLaurentienne
Department of Earth Sciences

## Faculty Position in Environmental Geoscience

The Department of Earth Sciences at Laurentian University invites applications for a tenure-track faculty position in Environmental Geoscience, effective July 1, 2007. We are interested in candidates with strengths in one or more of the following: groundwater resources, including hydrogeology; climate change (impacts and adaptations); application of geochemical and isotopic methods to environmental problems; tailings remediation and acid-rock drainage; metals and contaminants in the environment; Quaternary geology; and environmental impact assessment related to the above. An ability to interact with government, industry, and the community on environmental geoscience is an asset.

The candidate will teach in the interdisciplinary undergraduate Environmental Earth Science (ENES) program, and the undergraduate and graduate Geology programs. The candidate will be expected to have a strong interest in interdisciplinary education and research, and to provide leadership in the ENES Program. Supervision of M.Sc. and Ph.D. students within a vigorous, externally-funded research program is expected. Applicants must hold a Ph.D. degree by the time of appointment.

The successful candidate will be based in the Department of Earth Sciences, but an interest and ability to interact with faculty in the Centre in Environmental Monitoring and the Departments of Geography, Chemistry & Biochemistry, and Biology is of value. The candidate will have access to outstanding computing and geochemical analytical facilities, including a wide array of state-of-the-art ICP-AES, ICP-MS, LA-ICP-MS, XRD, SEM-EDS, and WD-EPMA instrumentation. A 3D immersion Virtual Reality Theatre for scientific data visualization is available (http://www.mirarco.org/aboutvr.php).

We will begin reviewing applications in early January 2007, but applications will be accepted until the position is filled. Applicants should send a signed Letter of Application, full curriculum vitae, a Statement of Research Interests, a Statement of Teaching Interests, and the names of three academic (3) references to: Dr. Harley d'Entremont, Vice-President Academic, Laurentian University, 935 Ramsey Lake Road, Sudbury, Ontario, Canada P3E 2C6. Email: hdentremont@laurentian.ca.
Further information regarding the ENES program and the Department of Earth Sciences can be found at www.laurentian.ca/calendar/EnviroEarthScience06.pdf and www.laurentian.ca/geology.

Laurentian University is a bilingual institution and an equal opportunity employer. It has a policy of passive bilingualism (English/French) as a condition of tenure. The university is committed to equity in employment and encourages applications from aboriginal peoples, members of visible minorities, and persons with disabilities.

## Call for Nominations for the Gold Medal and Past Presidents' Medal

Nominations for the AAG Gold Medal and Past Presidents' Medal are open until December 31, 2006. The Association awards these medals to worthy and deserving persons in accordance with the guidelines set out below:

**Gold Medal** - awarded to a person for outstanding scientific achievement in applied geochemistry.

**Past Presidents' Medal** - awarded to a member of the Association of Applied Geochemists for dedicated service to the Association.

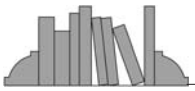
Acceptable nominations shall be signed by a minimum of four (4) Fellows (voting members) of the Association in good standing and shall include the following:

(a) A letter of nomination (to be signed by a minimum of four (4) Fellow (voting members);
(b) A resume or curriculum vitae of the nominee;
(c) An itemized list of the outstanding scientific achievements (Gold Medal) or the dedicated service to the Association (Past Presidents' Medal) of the nominee.
(d) Other pertinent documentation relevant to these achievements and/or qualifications of the nominee may include endorsements from other individuals whether or not Fellows of the Association.

Since members of the Awards Committee may not have personal knowledge of the nominee, the completeness and quality of the nomination will be critical in evaluation and selection.

Nominations should be sent no later than December 31, 2006 to:

**David Kelley**
*Chairman, AAG Awards Committee*
*Newmont Mining Corporation,*
*Denver Exploration Office*
*357 Inverness Drive South,*
*Englewood, Colorado USA 80112*
*(T) +1-303-708-4822 • (M) +1-720-207-4391*
*(F) +1-303-708-4501*
*dave.kelley@newmont.com*



## RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in **EXPLORE** Number 132. Journals routinely covered and abbreviations used are as follows: Economic Geology (EG); Geochimica et Cosmochimica Acta (GCA); the USGS Circular (USGS Cir); and Open File Report (USGS OFR); Geological Survey of Canada papers (GSC paper) and Open File Report (GSC OFR); Bulletin of the Canadian Institute of Mining and Metallurgy (CIM Bull.): Transactions of Institute of Mining and Metallurgy, Section B: Applied Earth Sciences (Trans. IMM). Publications less frequently cited are identified in full. Compiled by L. Graham Closs, Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401-1887, Chairman AEG Bibliography Committee. Please send new references to Dr. Closs, not to **EXPLORE**.


Abdella, M.H., 2006. An overview on the REE-Mineralized Alkaline Granites in Egypt, with special references to the Abu Khrug and Gara El Hamra Bodies. Resource Geology. 56(3): 365-370.

Anon., 2006. Australian Mineral Economics – A Survey of Important Issues. Aus IMM Mono. 24. 240 p.

Bailey, J., McDonald, A.M., and Lafrance, B., 2006. Variations in Ni content in sheared magmatic sulfide ore at the Thayer Lindsley mine, Sudbury, Ontario. Can. Min. 44(5): 1063-1077.

Banfield, J.F., Cervini-Silva, J., and Nealson, K.M. (eds.), 2005. Molecular Geomicrobiology. Rev. Min. and Geochem. Min. Assoc. Am. V 59. 294 p.

Buccianti, A., Maten-Figueras, G., and Pawlawsky-Glahn, V. (eds.), 2006. Compositional Data Analysis in the Geosciences. Geol. Soc. (London). Spec. Pub. 264. 224 p.

Harris, J.R., et al., 2006. Gold prospectivity maps of the Red Lake greenstone belt: application of GIS technology. Can. J. Earth Sci. 43(7): 865-893.

Ishihara, S., et al., 2006. Resource Evaluation on Some Genetic Aspects of Indium in the Japanese Ore Deposits. Resource Geology. 56(3): 347-364.

Ishihara, S. and Mukakami, H., 2006. Fractionated Ilmenite-series Granites in Southwest Japan: Source Magma for REE-Sn-W Mineralizations. Resource Geology. 56(3): 245-256.

Ishihara, S. and Shimazaki, H. (eds.), 2006. A Special Issue on Granites and Metallogeny: The Chappell Volume. Resource Geology. 56(3): 197-370.

Janousek, V., Farrow, C.M., and Erban, V., 2006. Interpretation of whole-rock geochemical data in igneous geochemistry: Introducing geochemical data toolkit (GCD kit). J. Petrology. 47(6): 1255.

Kelley, D.L., et al., 2006. Beyond the Obvious Limits of Ore Deposits: The Use of Mineralogical, Geochemical, and Biological Features for the Remote Detection of Mineralization. EG. 101(4): 729-752.

Koike, K. (ed.), 2005. Special Issue on the Mathematical Geology for Resource Exploration. Natural Resources Research. 14(4):

Laznicka, P., 2006. Giant Metallic Deposits. Future Sources of Industrial Metals. Springer. 732 p.

Li, G, et al., 2006. Geology, Ar-Ar Age and Mineral Assemblage to Eocene Skarn Cu-Au-Mo Deposits in the Southeastern Gangdese Arc, Southern Tibet: Implications for Deep Exploration. Resource Geology. 56(3): 315-336.

Liebscher, A. and Franz, G. (eds.), 2004. Epidotes: Rev. Min. and Geochem., Min. Soc. Am. V. 56. 628 p.

Linnen, R. and Samson, I., 2005. Rare-Element Geochemistry and Mineral Deposits. Geol. Assoc. Can. Short Course Notes 17. 352 p.

Mao, J. and Bierlein, F.P. (eds.), 2005. Mineral Deposit Research: Meeting the Global Challenge. Proc. 8th Biennial SGA Meeting (Beijing). Springer. 2 Vol. 1613 p.

McDonald, A.J., et al., 2005. Mineral Deposits and Earth Evolution. Geol. Soc. (London). Spec. Pub. 248. 268 p.

Nealson, K.H. and Popa, R. (eds.), 2005. Special Issue on Microbial Biogeochemistry. Am. J. Sci. 305(6-8).

Ono, S., et al., 2006. High precision analysis of all four stable isotopes of Sulfur ($^{32}S$, $^{33}S$, $^{34}S$, $^{36}S$) at manomole levels using a laser fluorination isotope-ratio-monitoring gas chromatography-mass spectrometry. Chem. Geol. 225(1/2): 30-39.

Ott, N. et al., 2006. GIS analyses and favorability mapping of optimized satellite data in northern Chile to improve exploration for copper mineral deposits. Geosphere. 2(4): 236-

Parsons, M.B. and Percival, J.B., 2005. Mercury: Sources, Measurement, Cycles, and Effects. Min. Assoc. Can. Short Course 34. 320 p.

Ponthieu, M., et al., 2006. Metal ion binding to iron oxides. GCA 70(11): 2679-

Radhakrishna, B.P., 2006. Some thoughts on diamond exploration in India. J. Geol. Soc. India. 67(3): 283.

Relvas, J.M.R.S., et al., 2006. Hydrothermal Alteration and Mineralization in the Neves-Corvo Volcanic-Hosted Massive Sulfide Deposits, Portugal. I. Geology, Mineralogy, and Geochemistry. EG 101(4): 753-790.

Robb, L., Cailteax, J., and Sutton, S. (eds.), 2005. Special Issue on Recent Advances in the Geology and Mineralization of the Central African Copperbelt. J. Afri. Earth Sci. 431(1-5).

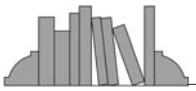
Samson, I.M., Cioppa, M.T., and Symons, D.T.A. (eds.), 2006. Proceedings GEOFLUIDS V. 5th International Conference on Fluid Evolution, Migration, and Interaction in Sedimentary Basins and Orogenic Belts. J. Geochem. Explor. 89(1-3)

Sato, K., Rodionov, S.M., and Brublevsky, A.A., 2006. Lermontovsko Tungston Skarn Deposit: The Oldest Mineralization in the Sikhote-Alin Orogen, Far East Russia. Resource Geology. 56(3): 257-266.

Schmidt, M.W., et al., 2006. Element partitioning: The role of melt structure and composition. Science 312: 1646-

Setijadji, L.D., et al., 2006. Cenozoic Island Arc Magmatism in Java Island (Sunda Arc, Indonesia): Clues on Relationships between Geodynamics of Volcanic Centers and Ore Mineralization. Resource Geology. 56(3): 267-292.


continued on page 26



## RECENT PAPERS

continued from Page 25

Shragge, J. and Snow, C.A., 2006. Bayesian geochemical discrimination of mafic volcanic rocks. Am. J. Sci. 306(1-5): 191-

Spadoni, M., 2006. Geochemical mapping using a geomorphologic approach based upon catchments. J. Geochem. Explor. 90(3): 183.

Sprague, K., et al., 2006. Spatical targeting using queries in a 3-D GIS environment with application to mineral exploration. Computers and Geosciences 32(3): 396-

Stanton, R.L., 1006. On limits to distances of movement of matter during regional metamorphism: An investigation of nine samples from high-grade metamorphic terranes. Can. Min. 44(5): 985-1024.

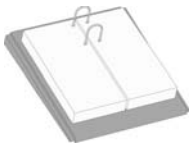
Vaughan, D.J. (ed.), 2004. Sulfide Mineralogy and Geochemistry. Rev. Min. and Geochem. Min. Soc. Am. V. 61. 714 p.

Vermeesch, P., 2006. Tectonic discrimination diagrams revisited. Geochemistry, Geophysics, Geosystems, $G^3$ 7 (June 27).

Vigneresse, J.L., 2006. Element Mobility in Melts during Successive Intrusions of Crustal-derived Magmas and Sn-W Mineralization. Resource Geology. 56(3): 293-314.

Vikent'ev, I.V., Moloshag, V.P., and Yudovskaya, M.A., 2006. Speciation of noble metals and conditions of their concentration in massive sulfide ores of the Urals. Geol. of Ore Deposits. 48(2): 77.

Zhang, Q., et al., 2006. Indium Enrichment in the Meng'entaolegai Ag-Pb-Zn Deposit, Inner Mongolia, China. Resource Geology. 56(3): 337-346.



## CALENDAR OF EVENTS

International, national, and regional meetings of interest to colleagues working in exploration, environmental and other areas of applied geochemistry. These events also appear on the AAG web page at: www.appliedgeochemists.org

### 2007

• January 29 - February 1, 2007 **Mineral Exploration Roundup 07.** Vancouver, B.C. Canada. Website: http://www.amebc.ca/roundupoverview.htm

• Feb 24-28, 2007. **The Second International Conference on Geo-Resources in The Middle East and North Africa,** Cairo University, Cairo, Egypt. Website: http://www.grmena.com.eg

• March 4-7, 2007. **Prospectors and Developers Association of Canada Annual Convention,** Toronto, Canada. Website: http://www.pdac.ca

• April 1-4, 2007. **10th International Symposium on Wetland Biogeochemistry: Frontiers in Biogeochemistry**, Annapolis, Maryland, USA Website: http://www.serc.si.edu/conference/

• April 29 to May 2, 2007. **2007 Canadian Institute of Mining and Metallurgy Annual Conference and Exhibition** Website: http://www.cim.org

• May 23-25, 2007. **Joint Annual Meeting Geological Association of Canada- Mineralogical Association of Canada**, Yellowknife, Northwest Territories, Canada. Website: www.nwtgeoscience.ca/yellowknife2007/

• May 27-31 2007. **IMWA Symposium: Water in mining environments**. Cagliari, Sardinia, Italy. University of Cagliari, Department of Earth Sciences,
E-mail: Rosa Cidu @ cidur@unica.it

• June 14-19, 2007. **23rd International Applied Geochemistry Symposium,** Oveido, Spain **Contact:** Jorge Laredo, University of Oviedo, Spain. Email: jloredo@correo.uniovi.es

• August 13-18, 2007. **WRI-12 International Symposium on Water-Rock Interaction,** Kunming, China. Website: http://www.wri12.org

• August 19-24, 2007. **Goldschmidt 2007 - *"Atoms to Planets*** "Cologne, Germany Website: http://www.goldschmidt2007.org/

• August 20- 24, 2007. **SGA Meeting - 9th Biennel** Dublin, Ireland. Website: http://www.cpregistrations.com/sga2007

• September 9-12, 2007. **Exploration 07** Toronto, Canada. Website: http://www.exploration07.com/

• September 24-30, 2007. **AGS-2007 Symposium: Ores and Orogenesis-CircumPacific Tectonics, Geologic Evolution and Ore Deposits**. Tucson, Arizona, USA Website: http://www.agssymposium.org

• October 22-24, 2007. **World Gold 2007** Cairns, Australia. Website: http://www.ausimm.com/gold2007

• October 28-31, 2007. **GSA Annual Meeting, Earth Sciences for Society Beginning of the International Year of Planet Earth** , Denver, Colorado, USA website: http://www.geosociety.org/meetings/2007/

• November 27-29, 2007. **6th Fennoscandian Exploration & Mining FEM 2007** Lappia Hall, Rovaniemi, Finland. Website: www.lapinliitto.fi/fem2007/index.htm

### 2008

• July, 2008. **SEG-GSSA 2008 Resurgence of Economic Geology and the Minerals Industry in Africa,** Joint Conference of the Geological Society of South Africa and SEG Incorporating GEOFORUM 2008. Johannesburg, South Africa. Website: http://www.seg-gssa2008.org/

• August 5-14, 2008. **33rd International Geological Congress**, Oslo, Norway. Website: http://www.33igc.org.

• July 13 - 18, 2008 **Goldschmidt 2008** Vancouver, BC, Canada. Web site: (forthcoming)

Please let us know of your events by sending details to:

**Beth McClenaghan**
*Geological Survey of Canada*
*601 Booth Street*
*Ottawa, Ontario*
*CANADA K1A 0E8*
*Email: bmcclena@nrcan.gc.ca*
*613-992-7805*




# Invitation

Exploration 07 is the fifth in a series of once-a-decade meetings organized by the Canadian mineral exploration community to review the major advances in exploration technology made over the previous 10 years.

Designed with the global exploration community in mind, earlier meetings were attended by up to 1,000 delegates from as many as 60 countries. In addition to a world-class set of presentations and supporting workshops, a full documentation of the proceedings is one of the established traditions of these decennial reviews.

As with previous meetings, Exploration 07 will present the state of the art in exploration technology, with the focus on geophysics, geochemistry, remote sensing, data processing and integration and the application of these disciplines to ore discovery.

The organizing committee of Exploration 07 invites its colleagues from around the world to convene in Toronto in September 2007 to network with their international colleagues, build on their exploration expertise and to celebrate another 10 years of advancement of the exploration geosciences.

## Theme

Exploration 07 will review the current state of the art in geophysics, geochemistry, remote sensing, data processing and integration. Given the industry-wide emphasis of better integration of scientific capabilities and business imperatives, the meeting will seek to highlight the strategic linkage between the technological and commercial sides of the exploration industry from primary ore discovery to risk management through the entire mining cycle.

## Who Should Attend

The activities of Exploration 07 will be of interest and value to a wide spectrum of stake holders in mineral exploration, including geologists, geochemists, geophysicists as well as managers, academics and government scientists involved with mineral exploration and mining-related environmental programs.

### Information and Registration

To receive the information that you will need to participate as a delegate or exhibitor to Exploration 07, you should fill in the form on the information booklet and fax it back to the organizing committee at 1-905-474-1968, or email your contact details and items of interest to: interest@exploration07.com

# 23rd INTERNATIONAL GEOCHEMICAL EXPLORATION SYMPOSIUM and 2nd INTERNATIONAL APPLIED GEOCHEMISTRY SYMPOSIUM

23rd IGES 2007
Exploring our Environment

## EXPLORING OUR ENVIRONMENT

***Jointly organized by the Department of Exploration and Mining of the University of Oviedo (Spain), the Geological and Mining Institute of Spain (IGME) and the Association of Applied Geochemistry***

### 14 – 19 JUNE 2007. PRÍNCIPE FELIPE CONFERENCE HALL OVIEDO, ASTURIAS. SPAIN

## Preliminary Announcement

Technical Sessions
Poster and Trade Exhibition
Workshops
Social Programme
Field Visits
Accompanying Persons Programme

*INVITATION TO EXPLORE OUR ENVIRONMENT*

The 23rd International Geochemical Exploration Symposium and 2nd International Applied Geochemistry Symposium will be held in Oviedo (Spain) from 14th to 19th June 2007.

Oviedo, with 215,664 inhabitants, is the capital of Asturias, in northern Spain. The Symposium will take place in the Conference Hall of the City, located in the heart of Oviedo and within walking distance to hotels and amenities.

The Organizing Committee has planned an assorted program about applied geochemistry, covering the last advances in geochemical techniques for mining exploration and environment. Pre- and post- symposium field trips are being organized combining both technical and tourist visits in Spain and Portugal. A full slate of workshops will take place on the week end between the Symposium (16th -17th June). An exciting social and cultural program will be organized for participants and accompanying persons, including a full program of one-day tours to places of interest in the region.

On behalf of the Organizing Committee and the Association of the Applied Geochemistry, I have great pleasure to invite you to join us in Oviedo in June 2007 to participate in this Symposium. We look forward to meeting you in Oviedo next year.

Jorge Loredo
23rd IGES Chairman

# ioStipend

## *In-kind Analytical Research Fund for BSc(Hons), MSc and PhD students*

Much has been said and written about the broadening gulf between the demand for qualified explorationists and the supply coming out of our colleges, technical institutes and universities. One merely has to attend any geo-conference and gaze out over the sea of grey to fully grasp the situation our industry faces. This is all the more evident in the field of exploration geochemistry whose members have always been in short supply.

As consultants and service industries, we owe our livelihood to mining and exploration and thus have a vested interest in its development. We believe that any aid to promote fresh faces into our sector is helping to secure our future.

**Acme Analytical Laboratories Ltd**. and **ioGlobal** are taking the bold initiative of directly aiding students in the geosciences via the **ioStipend**. The **ioStipend** is a grant available to students conducting exploration-related geochemical studies at a recognized educational institution. The grant is in the form of analytical services using any package provided by Acme Analytical Laboratories Ltd. Students and/or their teachers/advisors can apply for the grant by submitting the application to ioGlobal who will vet the proposals.

The grant is intended to promote the collection of high quality, base-line data for comparison with more "esoteric data" (eg, isotopic data, partial digests, non-standard sample media) generated during the course of research, and to promote broad training in fundamental geochemical principals across the geosciences.

The **ioStipend** allows for amounts of approximately $5,000 (AUD, CAD or equivalent) for in-kind analytical work. Successful applicants will also be provided with 3 academic licences of **ioGAS**, the new exploratory data analysis software package available from ioGlobal.

The application form is available at www.ioglobal.net.

It is envisaged that three or four of these awards will be made each year.

Applications are reviewed by an expert group of ioGlobal's geochemists

**Eligibility Criteria**

Preference will be given to:

- students with no other source of funding
- students working on exploration geochemistry projects
- projects no or very minimal confidentiality requirements

The ioStipend is international. Applications are welcome from qualified institutions globally.

Some technical input may be provided by ioGlobal on request.

**Requirements for receiving the ioStipend**

Firstly, there are minimal strings attached. Recipients would have to agree to

1. Have their project promoted on the ioGlobal web site in an area devoted to R&D carried out under the program (couple of passport photo shots, brief description)
2. Acknowledge ACME Labs and ioGlobal for support in technical and public presentations of results
3. Write a short article for Explore describing the project outcomes, and allow this to be published on the ioGlobal web site.

**David Lawie, John Gravel**

# *Association of Applied Geochemists*
# APPLICATION FOR MEMBERSHIP*

Please complete only the relevant section for membership. See below for mailing instructions.

I, _____, wish to apply for election as a ___Member / ___Student Member of the Association of Applied Geochemists. I have read the Code of Ethics of the Association and in the event of being elected a Member/ Student Member agree to honour and abide by them.

**MEMBER:** *State Employer and Employee title*
I am actively engaged in scientific or technological work related to applied geochemistry exploration and have been so for the past two years.
_____ as a _____.
(employer) (employment title)

**STUDENT MEMBER:** *Student status must be verified by a Professor of your institution or a Fellow of the AAG*
I certify that the applicant is a full-time student at _____ in pure or applied science.
(institution)

_____ _____
(Professor/ AAG Fellow Signature ) (Printed Name and Title)

Witness my hand this _____ day of_____, 20_____. _____
(Signature of applicant)

**NAME AND ADDRESS**: PLEASE PRINT (to be completed by applicant)

Name: _____ Telephone bus: _____

Address: _____ fax: _____

_____ home: _____

_____ e-mail: _____

**Annual Dues** :

All applications must be accompanied by annual dues . All payments must be in US funds. Select one of the four listed below.

| | | | | |
|---|---|---|---|---|
| 1 | 2007 member dues | US$ | 100 | _____ |
| 2 | 2007 student member dues | | 10 | _____ |
| | - If receipt required, include a self-addressed envelope and add | | 2 | _____ |
| | - If your check is not drawn from a U.S.A. or Canadian bank, add | | 15 | _____ |
| | | | **TOTAL** | _____ |

Payment by check, International Money Order, UNESCO Coupons, International Postal Orders, VISA, American Express and Master Card are acceptable. For credit cards users, minor variations in your billing may reflect currency exchange rate fluctuations at time of bank transaction.

Type: VISA ___ American Express ___ Master Card ___ Credit card account number: _____
Expiry date: _____ Name: _____ Signature: _____

***Application for voting membership requires the sponsorship of three voting members. Request a voting member application from the Association office.***

**Please note**: Your application form will be acknowledged upon receipt. The Admissions Committee reviews all applications and submits recommendations to Council, who will review these recommendations at the next Council Meeting or by correspondence. If no objection is raised the names, addresses and positions of candidates will be listed in the next issue of the AAG Newsletter. If after a minimum of 60 days have elapsed following submission of candidate information to the membership no signed letters objecting to candidates admission are received by the Secretary of the Association from any Member, the Candidate shall be deemed elected, subject to the receipt by the Association of payment of required dues. Send completed application, together with annual dues to:

*Association of Applied Geochemists*
**P.O. Box 26099, 72 Robertson Road, Ottawa, Ontario, CANADA K2H 9R0**
TEL: (613) 828-0199, FAX: (613) 828-9288, email: office@appliedgeochemists.org WEBSITE: http://www.appliedgeochemists.org

EXPLORE

Newsletter No. 133 DECEMBER 2006

Editor: Beth McClenaghan (bmcclena@nrca.gc.ca)

Assistant Editors:
Barry Smee (bwsmee@attglobal.net)
Sean McClenaghan (ventcomplex@hotmail.com)

Business Manager:
David Seneshen, (303) 277-1694
(dseneshen@directgeochemical.com)
Back Issues contact: Betty Arseneault
(office@appliedgeochemists.org)

**EXPLORE** is published quarterly by the Association of Applied Geochemists, P.O. Box 150922, Lakewood, CO 80215-0922, USA.

**EXPLORE** is a trademark of the Association of Applied Geochemists.

**Type and layout of EXPLORE**: Vivian Heggie, Heggie Enterprises, Thornton, CO (303) 288-6540; <vjmheggie@comcast.net>



# *LIST OF ADVERTISERS*



## THE ASSOCIATION OF APPLIED GEOCHEMISTS

**P.O. Box 26099, 72 Robertson Road, Nepean,**
**Ontario K2H 9R0 CANADA • Telephone (613) 828-0199**
**www.appliedgeochemists.org**

### OFFICERS

January - December 2006



### COUNCILLORS

*Councillor Emeritus*
Sherman Marsh

2005-2006
Phil M. Baker
Stephen J. Cook
Robert G. Eppinger
Jorge Loredo
Olle C. Selinus
David Seneshen

2006-2007
Ray Lett
Cliff Stanley
David Lentz
David Garnett
William Coker

*Brazil*
Germano Melo Jr.
*Chile*
Brian Townley
*China*
Xueqiu Wang
*Northern Europe*
J. B. De Smeth
*Southern Europe*
Benedetto De Vito
*Southeast Asia*
Iftikhar A. Malik
*Southern Africa*
Charles Okujeni
*UK and Republic of Ireland*
Deirdre M. A. Flight

### COMMITTEES

***Australian Geoscience Council Representative***
David Garnett

***Awards and Medals Committee***
*Chair:* David Kelley
William Coker
David Lentz
Barry W. Smee
Xueqiu Wang

***Bibliography Committee***
L. Graham Closs, *Chair*
Robert G. Garrett
Richard K. Glanzman
Eric C. Grunsky
Peter J. Rogers

***Distinguished Lecturer Committee***
Jeffrey Jaacks, *Chair*

***Election Official***
Sherman Marsh

***EXPLORE***
Beth McClenaghan, *Editor*
*email: bmcclena@nrcan.gc.ca*
Sean McClenaghan, *Assist. Editor*
Barry Smee, *Assist. Editor*
David Seneshen, *Bus. Manager*

***Geochemistry: Exploration, Environment, Analysis***
Gwendy E.M. Hall, *Editor-in-Chief*
*e-mail: Ghall@nrcan.gc.ca*

***Admissions Committee***
Nigel Radford, *Chair*
Paul Morris
Cliff Stanley

***New Membership Committee***
Robert Jackson, Chair

***Regional Councillor Coordinator***
Robert Bowell

***Short Course Committee***
Colin E. Dunn, *Co-Chair*
Vlad Sopuck, *Co-Chair*

***Student Paper Competition***
*Chair:* Dave Cohen
J.B. de Smeth
Paul Morris
Owen Lavin

***Symposium Committee***
Paul Morris, *Co-Chair*
Nigel Radford, *Co-Chair*
Eion Cameron
Mario Desilets
Philippe Freyssinet
Gwendy Hall
Virginia McLemore
Barry W. Smee
Graham F. Taylor

***Web Site Committee***
Robert Eppinger, *Chair*
*Webmaster:* Andrew Ransom

**Betty Arseneault,** *Business Manager*
P.O. Box 26099, 72 Robertson Road, Nepean, ON K2H 9R0 CANADA,
TEL: (613) 828-0199 FAX: (613) 828-9288, e-mail:
office@appliedgeochemists.org

EXPLORE

*Newsletter for The Association of Applied Geochemists*

P.O. Box 150922, Lakewood, CO, 80215-0922, USA

Please send changes of address to:
Association of Applied Geochemists
P.O. Box 26099, 72 Robertson Road, Nepean, Ontario, K2H 9R0, Canada · TEL: (613) 828-0199 FAX: (613) 828-9288
e-mail: office@appliedgeochemists.org • http://www.appliedgeochemists.org

PR SRT STD.
U.S. POSTAGE
PAID
DENVER, CO
PERMIT NO. 3550